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An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2008

Évaluation du stock de crabe des neiges (*Chionoecetes opilio*) de Terre-Neuve et du Labrador en 2008

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ABSTRACT

Resource status was evaluated throughout NAFO (Northwest Atlantic Fisheries Organization) Div. 2HJ3KLNOP4R based on trends in biomass, recruitment and mortality. Multiple indices of these metrics were derived from a suite of data sources that include dockside-monitored landings, fisher logbooks, observer monitoring, pre-and post-season trawl surveys, broad-scale post-season trap surveys, localized inshore trap surveys, a vessel monitoring system (VMS), and biological sampling data from multiple sources. The resource was assessed separately for offshore and inshore areas of each NAFO Division, where appropriate (Div. 3KLP4R). Data availability varied among divisions and between inshore and offshore areas within divisions. Data were insufficient to evaluate resource status in Div. 3NO and in offshore Div. 4R. The 1995-2008 fall post-season multi-species surveys in Div. 2J3KLNO indicate that the exploitable biomass was highest during 1996-98. The more limited time series (1999-2008) from spring multi-species surveys in Div. 3LNOP also indicated a decline in exploitable biomass in the early years of the surveys. The spring and fall surveys both showed decreases in the exploitable biomass indices from 2001 to 2003-04, with little change until the fall index increased in 2007. Recruitment has recently increased overall and prospects remain promising. The survey abundance and biomass indices of pre-recruits have been increasing since 2005 due to increases in the south (Div. 3LNOPs). Longer-term recruitment prospects are uncertain but the spring and fall surveys indicate that there has been a decline in abundance indices of smallest males (<60 mm CW) in recent years that may indicate reduced biomass in the long-term. Trends in indices are described in detail for each division and conclusions are presented with respect to the anticipated effects of short term changes in removal levels on fishery induced mortality.

RÉSUMÉ

On a évalué l'état de la ressource dans les divisions 2HJ3KLNOP4R de l'OPANO (Organisation des pêches de l'Atlantique Nord-Ouest) en fonction des tendances relatives à la biomasse, au recrutement et à la mortalité. Les indices multiples de ces paramètres proviennent d'une série de sources de données, notamment des débarquements faisant l'objet d'une surveillance à quai, des journaux de bord des pêcheurs, de la surveillance effectuée par des observateurs, des relevés au chalut avant et après la saison de pêche, des relevés au casier à grande échelle après la saison de pêche, des relevés au casier localisés dans les eaux côtières, du Système de surveillance des navires (SSN) et des données d'échantillonnage biologiques tirées de sources multiples. On a évalué la ressource des zones du large et des zones côtières séparément pour chaque division de l'OPANO, le cas échéant (division 3KLP4R). La disponibilité des données varie en fonction des divisions ainsi qu'en fonction des zones du large et côtières à l'intérieure des divisions. Les données étaient insuffisantes pour évaluer l'état de la ressource dans la division 3NO et dans la zone du large de la division 4R. Les relevés d'automne plurispécifiques effectués après la saison de pêche dans les divisions 2J3KLNO de 1995 à 2008 indiquent que la biomasse exploitable de 1996-1998 était la plus élevée. Les relevés de printemps plurispécifiques effectués dans la division 3LNOP, dont la série chronologique est plus courte (1999-2008), indiquent également un déclin de la biomasse exploitable au cours des premières années de relevés. Les relevés de printemps et d'automne indiquent une diminution des indices de la biomasse exploitable de 2001 à 2003-2004, avec peu changement jusqu'à l'augmentation de l'indice d'automne en 2007. Le recrutement dans son ensemble a récemment connu une augmentation et les perspectives demeurent prometteuses. Les indices de la biomasse et de l'abondance des pré-recrues dérivés du relevé se sont accrus depuis 2005 en raison de l'augmentation observée dans le sud (divisions 3LNOPs). Les perspectives de recrutement à plus long terme sont incertaines, mais les relevés de printemps et d'automne indiquent un déclin des indices de l'abondance des plus petits mâles (< 60 mm LC) au cours des dernières années, ce qui peut annoncer une réduction de la biomasse à long terme. On décrit en détail les tendances relatives aux indices pour chaque division et on présente des conclusions en ce qui concerne les effets prévus qu'auraient des changements à court terme dans les niveaux de prélèvement sur la mortalité par la pêche.

INTRODUCTION

This document serves to assess the status of the snow crab (*Chionoecetes opilio*) resource surrounding Newfoundland and Labrador in NAFO Div. 2HJ3KLNOP4R. The information presented follows from a formal scientific assessment conducted during February 2009, focused upon determining the exploitable biomass of crabs available to the 2009 fishery (commencing in April 2009), as well as the fisheries of succeeding years.

Snow crab are sexually dimorphic, with males normally achieving larger sizes than females. Exploitable crabs consist of large males that have not molted within the past 6-12 months, as recently molted animals do not yield commercially acceptable meat content. The minimum legal size is 95 mm carapace width (CW); this regulation excludes females from the fishery and ensures a portion of the adult males remain available for reproduction.

Snow crab in Newfoundland and Labrador are part of a larger population in Canadian Atlantic waters, from southern Labrador to the Scotian Shelf (Puebla et al. 2008). However, as movements of individuals within the stock are limited, assessments are conducted at the NAFO Division level with inshore and offshore areas considered separately. This is intended to partially conform with management areas (Fig. 1) while accomodating different types and amounts of available information.

The Newfoundland and Labrador snow crab fishery began in 1967 and was limited to NAFO Div. 3KL until the mid 1980's. It has since expanded throughout Div. 2HJ3KLNOP4R and is prosecuted by several fleets. Management of the increasingly diverse fishery led to the development of many quota-controlled areas with over 3500 licence/permit holders under enterprise allocation by 1999. The fishery is prosecuted using conical baited traps set in long-lines. The minimum legal mesh size is 135 mm to allow small crabs to escape. Under-sized and soft-shelled crabs that are captured in traps are returned to the sea and an unknown proportion of those die.

Data from multi-species bottom trawl surveys, conducted during fall in Div. 2HJ3KLNO and during spring in Subdiv. 3Ps, are examined to provide information on trends in biomass, recruitment, production, and mortality over the time series. Multi-species survey indices are compared with other relevant indices derived from data from fisher logbooks, at-sea observers, vessel monitoring system (VMS), dockside monitoring, and inshore and offshore trap surveys, toward inferring changes in resource status for 2009 and beyond.

The snow crab resource declined during the early 1980's but recovered and remained very large throughout the 1990's. Resource declines have become evident in some areas in recent years but increases have occurred in the northern divisions (Dawe et al. 2009).

METHODOLOGY

MULTI-SPECIES SURVEY DATA

Data on total catch numbers and weight were derived from multi-species bottom trawl surveys conducted during fall in Div. 2HJ3KLNO and during spring in Subdiv. 3Ps. The trawl used in these surveys was changed to a Campelen shrimp trawl in the fall of 1995, and this trawl proved to be more efficient in sampling crabs than the previously used groundfish trawl. The fall post-season trawl survey was conducted annually in all divisions except in Div. 2H, where it was executed during 1996-99, 2004, 2006 and 2008. Snow crab sampling during spring Subdiv. 3LNOPs surveys did not begin until 1999. Spring (pre-fishery) trawl surveys are considered to be less reliable than fall (post-fishery) surveys because some population components are relatively poorly sampled during spring when mating and molting take place. For both fall and spring surveys, a set of strata common to all years was selected for analysis,which does not include inshore or deep strata (>730 m). The 2006 Div. 3NOPs spring survey was incomplete and has been omitted from analyses. In divisions where both a spring and a fall survey are conducted (Div. 3LNO), only data from fall surveys are used in this assessment.

Snow crab catches from each survey set were sorted, weighed and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. Individuals of both sexes were measured in carapace width (CW, mm) and shell condition was assigned one of four categories. (1) soft-shelled – these crabs had recently molted, have a high water content and are not retained in the fishery; (2) new-shelled - these crabs had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the current fishery until fall; (3) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (4) old-shelled – these crab have been available to the fishery for at least 2 years. Males that undergo their terminal molt in the spring will remain new-shelled throughout the fishing season of that year and will not be fully hardened until the following year. Therefore, new-shelled legal-sized crabs are not considered to be part of the exploitable biomass, in the current year, although it is recognized that some of these males are retained by the fishery late in the season. It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year ('skip molters') and so will develop 'older shells' between molts. For each year that a crab skips a molt, its eventual recruitment is delayed by a year.

Males were also sampled for chela height (CH, 0.1 mm). Males develop enlarged chelae when they undergo a final molt, which may occur at any size larger than about 40 mm CW. Therefore only males with small chelae will continue to molt and subsequently recruit to the fishery. A model which separates two 'clouds' of chela height on carapace width data was applied (Dawe et al. 1997) to classify each individual as either adult (large-clawed) versus adolescent or juvenile (small-clawed). This model is defined as:

$$CW = 0.0806 CH^{1.1999}$$

Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed. Occurrence of advanced stages of Bitter Crab Disease (BCD) was noted in both sexes based on macroscopic examination. In cases of unclear external characteristics, crabs were dissected and classified based on observation of the hemolymph. Observation of cloudy or milky hemolymph supported the classification of such specimens as infected.

We examined annual changes in biomass indices of legal-sized males, by shell condition toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt and remain as new-shelled immediate pre-recruits for the duration of the current year's fishery. They begin to contribute to the legal-sized intermediate-shelled group in the following year. Hence we would expect annual changes in biomass to be first seen in soft or new-shelled legal-sized males and to be followed by similar trends in intermediate and subsequently old-shelled males.

Indices were calculated from spring and fall surveys using STRAP (Smith and Somerton 1981), to represent the exploitable biomass and pre-recruit biomass. For spring (pre-season) surveys, these indices represent biomass for the immediately upcoming fishery in the current year whereas for fall (post-season) surveys the indices represent biomass for the next fishery in the following year. The exploitable biomass index was calculated as the survey biomass index of adult (large-clawed) legal-sized (>94 mm CW) males, regardless of shell condition. Adult males are terminally molted, so that no members of this category would molt in spring and all adults in the fall survey (including new-shelled adults) would be fully recruited to the fishery in the following year. The exploitable biomass index generated from spring survey data includes a component of new-shelled males that would not actually be retained by the fishery in the immediately upcoming fishery but would be fully recruited to the fishery in the following year.

The pre-recruit index was calculated by applying a 19 mm CW growth increment (Hoenig et al. 1994) to all adolescent (small-clawed) males larger than 75 mm CW caught in the surveys, before applying STRAP. The resultant pre-recruit index, from fall surveys, represents a component of legal-sized (>94 mm CW) males that would be recently-molted, (soft or new-shelled), and not recruited to the fishery of the next year, but would begin to recruit (as older-shelled males) in the following year. However, some of these recently-molted males would have remained adolescent, and so would molt one more time before achieving adulthood and subsequently recruiting to the fishery, as intermediate-shelled males, one additional year later (i.e., 3 years after the fall survey year).

These exploitable and pre-recruit biomass indices were calculated using the raw survey data. It is known that catchability of crabs by the survey trawl (i.e. trawl efficiency) is lower than 1 and varies with substrate type and crab size (Dawe et al. 2010). However, trends in raw ('unstandardized') indices are comparable to those in 'standardized' indices (Dawe et al. 2003), that partially account for effects of substrate type and crab size.

Projection of biomass indices from the survey year does not account for annual variability in natural mortality or in the proportion of adolescent males that do not molt in the following spring (skip-molters). It is assumed that all small-clawed males molt each year. For each survey series, biomass indices are comparable among years because only those survey strata common among all years were included in the analysis. Inshore survey strata were not included in calculating biomass indices because they were not surveyed in some years.

Spatial distribution was compared among years for Div. 2J3KLNO using the fall survey abundance index data. ACON (G. Black, pers. com.) was used to describe the distribution of exploitable (>94 mm CW adults) and pre-recruit (>75 mm CW adolescents) males as described above.

The ratio of the annual landings to the exploitable biomass index (projected from the fall survey of the previous year) was calculated by NAFO Division to provide an index of exploitation rate. This index overestimates absolute exploitation rate because the survey index underestimates absolute biomass. However long-term changes in these ratios may be interpreted as reflecting trends in exploitation rate within each division. It is recognized that annual changes in these ratios may be due to changes in catchability (i.e., trawl efficiency) rather than exploitation rate. However we feel that long-term trends (since 1996) provide a useful indication of trends in exploitation rates. Inshore commercial catches and data from inshore survey strata were not included in calculating the ratios because inshore survey strata were not surveyed in all years.

To examine size composition of males, spring and fall survey catches by carapace width were grouped into 3 mm CW intervals and adjusted up to total population abundance indices. Each size interval was partitioned, based on chela allometry, between juveniles plus adolescents (small-clawed) versus adults (large-clawed).

FISHERY LOGBOOK DATA

Data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Division, Policy and Economics Branch, Newfoundland Region of Fisheries and Oceans Canada. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Division. The CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and mesh size). Long-term trends in logbook CPUE are presented, as a fishery-based index of trends in biomass, separately for inshore and offshore areas (Fig. 1).

STRAP analysis was applied to logbook data in a fashion similar to it's application to the multi-species survey data to calculate exploitable biomass indices for inshore and offshore regions within each NAFO Division. These indices account for variability in area fished across years. An effective area fished of 0.0053 km^2 (Dawe et al. 1993), analagous to the area swept by a single trawl survey tow, was applied to extrapolate trap catch rates across the total fishing area. All comparisons of indices were conducted separately for inshore and offshore regions of each NAFO Division. The offshore logbook-based exploitable biomass indices were used for comparison with the offshore exploitable biomass indices from multi-species surveys, raw logbook CPUE, and in recent years, post-season trap survey catch rate and biomass indices. Similarly, trends in the inshore logbook-based exploitable biomass indices were compared with raw logbook CPUE, inshore research trap survey catch rates, and trap survey exploitable biomass indices.

The spatial extent of annual fishing effort for inshore and offshore areas of each NAFO Division was calculated from commercial logbooks. Sets were assigned to 5' x 5' cells based on logbook co-ordinates. The annual ratio of the total number of cells with fishing effort (≥1 set) to the total number of cells in each area was used as an index of spatial expansion or contraction and compared with trends in fishery CPUE.

To investigate the possible effect of thermal regime on snow crab production or early survival we compared CPUE with lagged (lag of best fit) temperature indices for each of Div. 2J, 3K, 3L, and Subdiv. 3Ps. The CPUE was a divisional index, generated from pooled inshore and offshore logbook data. We used two indices of thermal regime, bottom temperature and area of the CIL (Cold Intermediate Layer). Bottom temperatures used for NAFO Div. 3K and 3L were annual mean bottom temperatures from Station 27, located 10 nm off St. John's. Bottom temperatures used for Div. 2J and Subdiv. 3Ps were mean temperatures from bottom trawl survey sets, collected using a trawl-mounted CTD system. Only data from shallow-water sets (<200 m) were used because settlement and early benthic stages occur on shallow banks (Dawe and Colbourne 2002). Mean bottom temperatures for Div. 2J were derived using data from fall surveys, whereas those from Subdiv. 3Ps were derived using data from spring surveys. Area of the CIL was the cross-sectional area of the water column occupied by temperatures of <0 °C from oceanographic transects extending across the continental shelf (Colbourne et al 2009), representing Div. 2J (Hamilton Bank Section), 3K (Bonavista Section) and 3L (Grand Bank Section).

OBSERVER CATCH-EFFORT DATA

Set and catch data were available from the Observer Program for the same time series as those from the multispecies surveys (1995-2008), but at-sea sampling data have only been collected since 1999. Levels of sampling have increased in Div. 3KLNO in recent years due to increased observer coverage in offshore areas (Fig. 2). Sampling has been consistently lowest in Div. 4R

The observer set-and-catch database included details about number of traps, landed catch (kg) and discarded catch (kg) for each set observed. An observer-based CPUE index (kg. landed/trap haul) was calculated for comparison with inshore and offshore logbook CPUE.

For offshore areas, a pre-recruit fishing mortality index (PFMI) was developed based on the ratio of the observed catch rate of pre-recruits discarded in the fishery to the fall survey pre-recruit index of the previous year. This index is defined as;

$$PFMI = S\left(\frac{DPI_t}{PBI_{t-1}}\right)$$

where DPI is the catch rate (kg/trap haul) of pre-recruits (undersized and soft-shelled) discarded in the fishery, in year t, calculated from observer data. The PBI is the pre-recruit biomass index (t x 1000) from the fall survey of the previous year. The S is a scaling factor to account for incomplete and annually variable levels of observer coverage, defined as:

$$S = \frac{Total\ Landings}{Observed\ Landings}$$

The PFMI overestimates pre-recruit mortality because the PBI underestimates pre-recruit biomass, as a result of low catchability of pre-recruits by the survey trawl. However we feel that long-term trends in this index provide a useful indication of trends in pre-recruit mortality. In both inshore and offshore areas, the percent discarded (by weight) is viewed as an index of wastage in the fishery. It provides an indication of the level of wastage associated with catching and releasing pre-recruits in the fishery, and is not necessarily proportional to the mortality rate on the pre-recruit population.

Data were also examined from at-sea biological sampling by observers. Entire trap catches of males were sampled for carapace width (mm) and shell condition. Shell condition categories differed slightly from those described above for trawl surveys, in that categories of crabs not recently molted (intermediate-shelled and old-shelled in trawl surveys) were pooled into a single category. These biological sampling data were used to identify specific categories of discards (i.e., 'undersized' and 'soft' legal-sized) for comparison with total discards from observer set-and-catch data. Also, seasonal trends in the percentage of soft-shelled crabs were described. Discarding is believed to impose a high mortality on recently-molted (especially 'soft') immediate pre-recruits. A soft-shell protocol was implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%.

VESSEL MONITORING SYSTEM (VMS) AND DOCKSIDE MONITORING PROGRAM (DMP) DATA

Data on hourly vessel positions (VMS) and landed catch (DMP) were obtained and examined, for offshore areas only (Fig. 1), from the Fisheries Management Branch and the Policy and Economics Branch, Statistics Division, Newfoundland Region of Fisheries and Oceans Canada. These datasets were merged based on vessel registration number (VRN), year, month, and day. A CPUE index (kg/fishing hr.) was calculated by year and NAFO Division, as described by Mullowney and Dawe (2009). Fishing hours were screened based on location and speed from hourly positional signals. Signals occurring at 0.1–3.0 knot speeds were accepted as fishing signals. The VMS dataset consisted of a short (5 year) time series and was limited to offshore fishing fleets.

VMS-based CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and vessel drift) (Mullowney and Dawe 2009). Trends in VMS-based CPUE are presented as a fishery-based index of trends in biomass for offshore areas and compared with commercial logbook and observer-based CPUE indices.

TRAP SURVEYS

Data were available from an inshore Div. 3K trapping survey that was carried out in White Bay and Notre Dame Bay during 1994-2008, with the exception of 2001. The survey has consistently been conducted in September and occupies five of the inshore fall multi-species survey strata with a target of 8 sets per stratum. Each set includes six traps, with crabs sampled from two large-meshed (commercial, 135 mm) traps and two small-meshed (27 mm) traps. Catch rate indices (kg/trap haul) of legal-sized males were calculated by shell category (new-shelled recently-molted versus older-shelled), and size distributions were described by claw type (small-clawed juveniles plus adolescents versus large-clawed adults). Mortality was also inferred from levels of BCD observed in these surveys.

Data were also available from two inshore trap surveys (1979-2008) within Div. 3L. These surveys were conducted in different seasons; summer (Bonavista Bay), and fall (Conception Bay). For each survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping surveys.

Data were examined from industry-DFO collaborative post-season trap surveys in Div. 3KLPs4R (Fig. 3). These surveys, funded by the Fisheries Science Collaborative Program (FSCP), were examined for the first time in 2006 (Dawe et al. 2008). They were initiated following the 2003 fishery and have been conducted annually thereafter, beginning September 1st each year. The surveys, conducted by snow crab harvesters accompanied by at-sea observers, focus on commercial fishing grounds within individual CMAs. Survey stations are fixed and generally follow a grid pattern, with maximum station spacing of 5' X 5' (Fig. 3). At each station, 6 (inshore) or 10 (offshore) commercial (135 mm mesh) crab traps are set in a fleet. All crab caught are sexed and counted. Biological sampling of male crab is conducted at-sea, by observers, from two traps at each station. Sampling includes determination of carapace width, shell condition, leg loss and presence of BCD. Small-mesh traps are included at selected stations to collect information on pre-recruits and females. To control for annual variability in spatial coverage by the surveys, data analysis was limited to common stations occupied in multiple years (Fig. 3). In Div. 2J, only data from the Hawke Channel were captured, with sampling limited to 2007-08. No common stations were occupied in

Div. 3N, and sampling in Div. 3O was exclusive to the Whale Deep and Haddock Channel areas on the northwest portion of the Grand Bank (Fig. 3). Common stations were limited to the northern portion of offshore Subdiv. 3Ps, while in Div. 4R offshore sampling occurred only in 2003, 2007, and 2008. There was no inshore sampling in Div. 4R during 2005, and common stations were limited to three local CMAs in other years. Exploitable biomass indices were calculated from trap survey catch rates using the method described for the calculation of logbook-derived estimates; ie.using the estimated effective fishing area of a trap to spatially extrapolate catch rates across the entire fishing area. In the inshore of Div. 3KLPs, exploitation rates were calculated using the ratio of landings to the trap survey-based exploitable biomass estimates of the previous year.

RESULTS AND DISCUSSION

THE FISHERY

The fishery began in Trinity Bay (Management area 6A, Fig. 1) in 1967. Initially, crabs were taken as gillnet by-catch but within several years there was a directed trap fishery in inshore areas along the northeast coast of Div. 3KL from spring through fall. Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981, fishing was restricted to the NAFO Division where the licence holder resided. During 1982-87, there were major declines in the resource in traditional areas of Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps, and offshore Div. 3K. Since the late 1980's, the resource has increased in these areas. A snow crab fishery began in Div. 4R in 1993.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989, there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft., introduced in 1995, were converted to licences in 2003 and exploratory licences in the offshore were converted to full-time licences in 2008. There are now several fleet sectors and about 3350 licence holders. In the late 1980's, quota control was initiated in all management areas (Fig. 1) of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with fishing area regulations.

Landings for Div. 2HJ3KLNOP4R (Table 1, Fig. 4) increased steadily from 1989 to peak at 69,100 t in 1999, largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 44,000 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased by 20% since 2005 to 52,800 t in 2008, due primarily to increases in Div. 3K. Historically, most of the landings have been from Div. 3KL.

Effort, as indicated by estimated trap hauls, approximately tripled throughout the 1990's. It declined in 2000 and increased slightly thereafter. Increasing effort in the 1990's was primarily due to vessels <35 feet with temporary seasonal permits entering into the fishery. Effort has been broadly distributed in recent years (Fig. 5), but there has been a reduction in effort along the shelf slope in Divs. 2J3KNOPs since 2003 (Dawe et al. 2004). In 2007, there was little effort along the shelf edge of Div. 3O relative to previous years (Dawe et al. 2009), and this area remained unfished in 2008 (Fig. 5).

DIVISION 2HJ3KLNOPs

Spatial Distribution from Fall Multi-species Surveys (Division 2HJ3KLNO)

The fall distribution of exploitable males (legal-sized adults, Fig. 6) as well as immediate pre-recruits (>75 mm adolescents, Fig. 7) throughout NAFO Div. 2HJ3KLNO in 2008 was generally similar to the distribution pattern observed throughout 1997-2007, as previously described (Dawe et al. 2009, Dawe and Colbourne 2002) with some exceptions. Large males have consistently been virtually absent over a broad area of the shallow (<100 m) southern Grand Bank throughout the time series. In 2008, abundance of largest males (Fig. 6) was lower in the northernmost areas (Div. 2HJ) while increases occurred in the southernmost areas (Div. 3LNO) relative to previous years. Survey catches of pre-recruit males (Fig. 7) in 2008 were greatly increased in the southern divisions (Div. 3LNO) and remained similar or increased slightly in the northern divisions (Div. 2J3K) compared to 2007.

Trends in distribution over the 1995-2000 period were reviewed by Dawe et al. (2003) and Dawe and Colbourne (2002). These trends included gradual spatial shifts of highest densities of most size groups, but also sharp annual and area-specific changes in survey catch rates. Such sharp area-specific annual changes in density that occur across both sexes and the entire broad male size range imply spatial and annual variability in catchability by the survey trawl (Dawe and Colbourne 2002).

Biomass

The multi-species trawl surveys indicate that the exploitable biomass declined from the late 1990's to a low level during 2003-05, but has since increased. The fall post-season surveys in Div. 2J3KLNO (Fig. 8) indicate that the exploitable biomass was highest during 1996-98. The more limited time series from spring multi-species surveys in Div. 3LNOPs (Fig. 9) also indicated a decline in exploitable biomass in the early years of the surveys. The spring and fall surveys both showed decreases in the exploitable biomass indices from 2001 to 2003-04, with little change until the fall index increased in 2007.

Recruitment

Recruitment has recently increased overall and prospects remain promising. The abundance and biomass indices of pre-recruits have been increasing since 2005 in both the fall (Fig. 8) and spring (Fig. 9) surveys due to increases in the south (Div. 3LNOPs).

Longer-term recruitment prospects are uncertain but the spring and fall surveys indicate that there has been a decline in abundance of smallest males (<60 mm CW) in recent years that may indicate reduced biomass in the long term (Figs. 10-13).

We feel there is higher uncertainty associated with the pre-recruit index than with the exploitable biomass index. This difference in uncertainty is not due to differences in precision of estimates but is primarily related to differences in molt status between the two groups. The exploitable biomass index is comprised exclusively of males that were terminally-molted adults in the surveys, whereas the pre-recruit index includes a large component of males that were adolescents as small as 76 mm CW during the surveys. The projection of the pre-recruit index assumes that all those adolescents will molt, survive, grow by 19 mm CW and subsequently recruit (over the following 2 years, involving yet an additional molt for those that remained legal-sized adolescents, as older-shelled males. In reality, the biomass of new-shelled pre-recruit crabs is greatly affected by annual variability in natural mortality, growth increment, and proportions that fail to molt. These variables currently cannot be predicted and so are not accounted for.

Low bottom temperatures promote terminal molt at small sizes in snow crab, resulting in relatively low recruitment from a given year class (unpublished data). However recruitment is more strongly affected by the positive effects of a cold regime on year class production than it is on the negative effects of a cold regime on size-at-terminal molt. Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years (Dawe et al. 2005, 2008) suggesting that cold conditions early in the life history are associated with the production of strong year classes and subsequent strong recruitment. Temperatures on the Newfoundland Shelf were below normal in most years from the mid-1980's to about 1995. These were years of high crab productivity that led to high commercial catch rates during the 1990's. A warm oceanographic regime has persisted over the past decade (Colbourne et al. 2009) implying poor long-term recruitment prospects.

Productivity of crab during early life history has also been linked to the winter and spring sea ice cover on the Newfoundland Shelf. The formation and melting of sea ice greatly influences the layering of the water column and, hence, the maintenance of primary and secondary production during spring within the near-surface layer (<50 m). It has been hypothesized that an important mechanism determining snow crab larval survival is a combination of nutrient supply, production of zooplankton, and physical oceanographic processes.

Mortality

Bitter Crab Disease (BCD) has been observed in snow crab, based on macroscopic observations, at low levels throughout 1996-2008. The prevalence and distribution of this parasitic disease throughout the Newfoundland-southern Labrador Continental Shelf (Div. 2J3KLNO) has been described in detail by Dawe (2002).

There had been a broadly-distributed incidence of bitter crab disease during 1996-2006, but the distribution became limited to localized aggregations, primarily to Div. 3K and 3L in 2007 (Fig. 14). In 2008, BCD prevalence increased in offshore portions of Div. 2J and Div. 3K. This disease, which is fatal to crabs, primarily occurs in new-shelled crab of both sexes and appears to be acquired during molting (Dawe 2002).

It is unknown how well apparent disease prevalence in trawl-caught samples represents true prevalence in the population, as identification has been based on recognition of external characteristics in chronic cases. It seems likely that our observations underestimate true prevalence. Relationships of prevalence with density are unclear (Dawe 2002) and implications for mortality are unknown.

DIVISION 2H

The Fishery

Landings, since 2005, peaked at 193 t in 2007 (Table 2, Fig. 15). A commercial TAC was first established in 2008, at 100 t, and landings totalled 140 t (Table 2). Landings in previous years were taken under exploratory fishing allocations Effort has increased each year since 2005 to its highest level of about 17,200 trap hauls in 2008 (Table 2, Fig. 15).

From 2005 to 2007 the fishery was concentrated along the slope edge, east of the Makkovik Bank (Fig. 16). However, in 2008 there was a shift with much of the effort occurring west of the Makkovik Bank closer to shore in the southern portion of the division.

There has been no clear trend in the timing of the fishery but effort has been greatest in late July to mid August during each of the past 3 years (Fig. 17). The timing of the fishery in this division is likely heavily influenced each year by ice.

Biomass

Logbook catch rates (CPUE) were variable and sporadic from 1995-2003, likely reflecting low levels of fishing activity (Table 2, Fig. 18). The CPUE increased steadily from 2004 to 2006 as effort increased, but has since declined to the long-term average. In 2008, highest catch rates occurred west of the Makkovik Bank in a previously un-fished area (Fig. 16). The VMS CPUE index agrees with the logbook index, increasing from 2004 to a peak in 2006, and declining since (Fig. 19).

Over the past three years, catch rates have increased during the first few weeks of fishing before declining as the season has progressed (Fig. 20a). Peak catch rates have occurred after about 40–60 t of removals each year (Fig. 20b).

The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index doubled between 2004 and 2006, but has since decreased by 66% (Table 9, Fig. 21). This is consistent with trends observed in the logbook and VMS CPUE indices (Fig. 18).

Production

Recruitment. Recruitment has decreased since 2004 and is expected to be low over the next several years. We examined annual changes in biomass indices of legal-sized males from fall multi-species surveys, by shell condition (Fig. 22), toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt, and they begin to contribute to the legal intermediate-shelled group in the following year. Since 2004, new-shelled crabs have dominated the legal-sized population component, suggesting the fishery has been highly dependent upon immediate recruitment.

Size compositions from fall multi-species surveys (Fig. 23) show a clear pattern of modal progression since 2004. A group of large adolescents at about 68-104 mm CW in 2004 were present as legal-sized new-shelled adults in 2006 (Fig. 24). This group of legal-sized crabs was greatly diminished in 2008, with few sub-legal sized crabs captured in the survey. The fall survey pre-recruit index (Table 10, Fig. 25) has decreased steadily since 2004 to a low level in 2008. Therefore short-term recruitment is expected to be low.

Mortality

Exploitation. Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2009.

DIVISION 2J

The Fishery

Landings (Table 3, Fig. 26) peaked in 1999 at 5,420 t, decreased sharply to 3,680 t in 2000 and changed little to 2002, before declining to 2005. They increased by 60% from 1,500 t in 2005 to 2,400 t in 2008. Effort (Table 3, Fig. 26) increased from 2000 to a record high level in 2002-04. It decreased sharply in 2005 and further declined by 18% to 2008. Commercial CPUE (Table 3, Fig. 27) indicates that fishery performance has improved each year since 2004.

The 2008 fishery was concentrated in Hawke and Cartwright Channels, similar to 2006-07 (Fig. 28). In 2006-08 there was no fishery along the slope edge as there was in earlier years.

The fishery generally occurred progressively earlier from 2004 to 2006 (Fig. 29), with total effort expenditure decreasing over this time period. However, in 2007 and 2008, the fishery was about 2 weeks later starting (week 8) than in the previous 2 years. This was a result of unfavourable ice conditions in the spring of 2007 and 2008 off southern Labrador. Despite this, the fishery was completed relatively early, by week 21 in both years, and the total recorded effort expenditure was at its lowest level in 2008.

Effect of Ocean Climate Variability

Since the early 1980's, commercial CPUE in Div. 2J has been inversely related to bottom temperature (Fig. 30) and positively related to areal extent of the cold intermediate layer (CIL, Fig. 31) at seven-year lags. Since 2004 however, CPUE has increased considerably while the lagged bottom temperature has remained high and the areal extent of the CIL has fluctuated. This substantial improvement in fishery performance is not entirely due to change in the exploitable biomass, but is also partly due to the reduction in fishery removals during 1999-2005 (Fig. 26), a general trend toward earlier fishing seasons since 2003 (Dawe et al 2009), and reduced fishing effort since 2004 (Fig. 26), which jointly resulted in reduced fishing mortality on soft-shelled pre-recruits.

Biomass

Commercial catch rate (CPUE) has oscillated over the time series (Fig. 27), initially decreasing from 1991 to 1995, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It has increased steadily since 2004 to the long-term average. The increase in CPUE in recent years can be attributed to improved catch rates in and around Cartwright Channel in the north and Hawke Channel in the south (Fig. 28).

The commercial logbook, observer, and VMS CPUE indices all increased from 2004 to 2007 (Fig. 32). However the observer and VMS indices declined in 2008 while logbook CPUE increased. This may be somehow related to a greater contribution by small vessels to the logbook datasets than to the other datasets. VMS is exclusive to larger, offshore vessels and observer coverage is generally higher on larger vessels.

The spatial coverage of the fishery has been inversely related to commercial CPUE (Fig. 33). The percentage of available 5' x 5' cells occupied by the fishery declined abruptly from its highest level of 19% in 2004 to its lowest level of 8% in 2006 and changed little since. The inverse relationship between spatial coverage of the fishery and commercial CPUE could be a function of fisher searching behaviour. It is likely that some fishers will search for new or alternate fishing grounds when catch rates are low or in decline. Conversely, when catch rates are high, there would be little need to search for alternate fishing grounds.

Commercial logbook CPUE has been higher throughout the season during the past three years than in 2004-06, with consistency in trends with both weekly (Fig. 34a) and cumulative catch (Fig. 34b). Trends in VMS CPUE throughout the season (Fig. 35) agreed with logbooks, that catch rates were generally higher initially and throughout the season in 2007-08 than in the previous 3 years according to trends with both weekly (Fig. 35a) and cumulative catch (Fig. 35b).

Trends in the logbook-based mean catch rate from the STRAP analysis (Fig. 36) reflected raw logbook CPUE, increasing steadily since 2004. These trends were consistent in both the common strata (strata fished in all years) and all strata (all strata fished in a given year) analyses, indicating the increase in catch rates has occurred throughout much of the division.

Size distributions from at-sea sampling by observers (Fig. 37) show decreasing catch rates of legal-sized males from 1999-2004, reflecting the trend in CPUE (Fig. 27). Modal CW decreased from about 110-113 mm in 2002 to about 92-95 mm in 2004 reflecting depletion of legal-sized males and suggesting an increase in pre-recruits. Modal CW then increased to 101 mm in 2005, and subsequently to 110 mm in 2008 with an overall increase in abundance of legal-sized animals, reflecting an increase in the exploitable biomass as members of a recruitment pulse molted and grew to large sizes.

The increase in observer catch rate of legal-sized males in 2006 was due to an increase in catch rate of old-shelled crabs (Fig. 38a). Further increase in catch rate in 2007-08 was due to a sharp increase in new-hard-shelled crabs, while the catch rate of old-shelled crabs decreased sharply (Fig. 38a). This suggests some inconsistency in shell condition classification because an increase in abundance of old-shelled crabs should be preceded by an increase in new-hard-shelled crabs. Shell condition classification is highly subjective and the 3-stage scale used by observers (since 2000) is one that includes the intermediate-shell stage (of the 4-stage scale used during surveys) with the old-shell stage. When the new-hard and old-shelled categories from at-sea sampling are pooled (Fig. 38b), their combined catch rate agrees well with observed CPUE during 2003-08. It is unclear to what extent this reflects misclassification of some new-hard-shelled crabs (shell 2) as old-shelled (shell 3) crabs versus retention of some new-hard-shelled crabs by the fishery.

The exploitable biomass decreased in 2008. The post-season trawl survey exploitable biomass index (Table 11, Fig. 39) decreased steadily, by 94%, from 1998-2002. It increased from 2002 to 2007, remaining below levels observed prior to 2002. This index and the post-season trap survey index both decreased in 2008 (Fig. 39). However, the post-season trap survey index is limited to only two years and reflects only the Hawke Channel portion of the fishery. The increase in the fall survey exploitable biomass index from 2002 to 2007 (Fig. 39), was small relative to the increase in CPUE indices (Fig. 27). This reflects effects of recent changes in the fishery on fishery performance (CPUE) as described earlier.

The industry-DFO collaborative post-season trap survey catch rates of legal-sized crabs, from stations common to 2007 and 2008 (Fig. 40), showed the decline in exploitable crabs occurred primarily in new-shelled crabs, with a slight increase in old-shelled males in the population in 2008.

Production

Recruitment. The post-season trawl survey indicates that the component of the exploitable biomass that represents immediate recruits (new-shelled legal-sized crab) decreased in 2008, following an increase since 2002 (Fig. 41). This is consistent with trends in the post-season trap survey (Fig. 40) and suggests that recruitment will decrease in 2009. Males enter the legal-size group as soft-shelled crabs, after the spring molt, and they begin to contribute to the legal intermediate-shelled group in the following year. Trends in the biomass index by shell condition reflect this process, in that the biomass of new-hard-shelled males peaked in 1998 whereas that of intermediate-shelled males peaked one year later, in 1999. The biomass index of new-hard-shelled males dropped sharply in 1999, whereas biomass of intermediate-shelled crabs declined steadily during 1999-2002. The biomass of new-hard-shelled crabs increased steadily from 2002 to 2006 while the biomass of older-shelled crabs remained low. This suggests that the fishery has been highly dependent upon immediate recruitment.

The size compositions from the post-season trap survey (Fig. 42) show a decrease throughout the size range of sub-legal and legal-sized crabs from 2007 to 2008 most prominent in new-shelled males. The size compositions from fall multi-species surveys (Fig. 43) are examined with the abundance index (ordinate) truncated for smallest males (<50 mm CW), so as to focus on trends in abundance for larger males. The survey data indicate that most of the relatively abundant sub-legal sized adolescent males evident in 2004 achieved legal size in 2005-07. The abundance of crabs larger than 75 mm CW declined in 2008. Size distributions by shell condition (Fig. 44) show a decline in the proportion of intermediate and old-shelled crabs in the population from 1999-2001, with little change thereafter. The size distributions (Figs. 43-44) suggest that indices of smallest males (<50 mm CW) increased during 1999-2001 and remained at a very low level until 2006, before increasing in 2007 and 2008. A modal group of 75-92 mm CW pre-recruits in 2004 that developed into exploitable biomass during 2005-08 may have been derived from the large modal group of smallest males (<50 mm CW) males in 2001, but there has been no clear evidence of modal progression over the time series. Therefore long-term recruitment prospects are uncertain. However declining abundance of smallest males during 2003-06 (Figs. 43-44), together with the persistence of a warm oceanographic regime (Fig. 30), may suggest relatively poor recruitment prospects in the long-term.

The catch rates of sub-legal sized crabs changed little in observer samples in 2008 while total discards decreased substantially (Fig. 45), implying a decrease in discards of soft-shelled crabs.

The fall survey pre-recruit index decreased from 1998 to a lower level during 1999-2003 (Table 12, Fig. 46) before increasing sharply to a peak in 2004. It has since decreased to the 1999-2003 level in 2007-08. The catch rate of under-sized crabs in the post-season trap survey decreased from 2007-08 (Fig. 40). Therefore, recruitment is expected to decrease further in the next several years.

Reproduction. The percentage of mature females carrying full clutches of viable eggs (Fig. 47) has varied over the time series. It remained above 90% until 2000 (excepting the anomalous 1999 value). It declined from 94% in 2000 to 74-78% in 2001-03 before increasing back to 94% in 2004, but subsequently decreased to 59% in 2006. The index increased to 72% in 2007 and nearly 100% in 2008. It is unknown to what extent changes in fecundity affect subsequent abundance of settling megalopae.

Mortality

Exploitation. The exploitation rate index increased sharply from 2000 to 2003 before declining sharply from 2003 to 2005 and has since changed little (Fig. 48), implying relatively low fishery-induced mortality in 2008. Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2009.

Indirect fishing mortality. Fishery-induced mortality, on the pre-recruit as well as the exploitable populations, has decreased since 2003. The pre-recruit fishing mortality index (Fig. 48) increased sharply from 2001 to 2003, decreased sharply from 2003 to 2005, and has since decreased further to its lowest level in 2008. The percentage of the total catch discarded (Fig. 48) increased sharply in 2002, was unchanged in 2003, and further increased to a record high level in 2004. It has since declined sharply to its lowest level, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. The sharp decline since 2004 is related to earlier fishing seasons that result in reduced catches of new-shelled immediate pre-recruits.

Snow crabs that are caught and released as under-sized or legal-sized soft-shelled males in the fishery are subject to multiple stresses and have unknown survival rates. Time out of water, air temperature, water temperature and shell hardness all influence the mortality level on discarded snow crab (Miller 1977). Other environmental factors such as wind speed, sunlight and size of the crab may also influence survivability (Dufour et al 1997). Poor handling practices such as prolonged exposure on deck, dropping or throwing crab, as well as inducing limb loss because increased mortality levels associated with catching and discarding crabs. Recently-molted (soft-shelled) snow crabs are more subject to damage and mortality than hard-shelled crab (Miller 1977; Dufour et al 1997).

Overall, observed weekly levels of soft-shelled crab (Fig. 49) were much lower from 2006 to 2008 than during 2002-05, consistent with the trend in overall percent discarded (Fig. 48). Peaks in percentage of soft-shell occurred progressively earlier each year from 2002 to 2005 (Fig. 49). This trend may be related to annual changes in time of molting and abundance of pre-recruits. However it is likely also related to progressively earlier seasonal depletion of recruited (older-shelled) crabs in those years and resultant increased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies little wastage of soft-shelled crabs in the 2006-08 fisheries relative to earlier years.

The fishery has been prosecuted earlier in recent years than it was prior to 2006 (Fig. 50) despite being affected by spring ice conditions in some years. The bulk of the 2008 effort was expended from weeks 8-11, with two-thirds of the traps hauled in that period. All observer coverage occurred from weeks 8-11 in 2008. During this time, weekly observations of soft-shelled crab remained at low levels (Fig. 50).

An area of Hawke Channel (Fig. 51) has been closed to all fisheries except snow crab from 2003 to 2008. CPUE has trended similarly inside and outside the closed area since its inception.

Natural Mortality. (BCD). BCD occurs almost exclusively in recently-molted crabs (Dawe 2002). BCD in Div. 2J males (Fig. 51) has been most prevalent in small new-shelled crabs of 40-59 mm CW. Prevalence, in new-shelled crabs has generally been low in this area, usually about 2-3 percent occurrence for that size range, excepting 1999 and 2008, when 18% and 16% of new-shelled adolescents in that size group were visibly infected. Prevalence of BCD was virtually absent from Div. 2J in 2006-07 but increased considerably in 2008, to about the 1999 level.

DIVISION 3K

The Fishery

Offshore landings (Table 4, Fig. 53) have generally been higher than inshore landings by a factor of 3-5. Offshore landings peaked in 1999 at 17,900 t. They decreased to about 13,000 t in 2000-04, due to reduction in TAC. Landings decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch (Dawe et al. 2006). Landings almost doubled from 5,970 t in 2005 to 11,600 t in 2008. Effort increased sharply in 2004 and decreased sharply in 2005. It declined by 27% from 2005 to 2007 and increased by 12% in 2008.

Inshore landings (Table 4, Fig. 53) peaked in 1999 at 3460 t and decreased sharply in 2000 due to a TAC reduction. They increased to 3,585 t in 2003, changed little in 2004, and decreased by 23% in 2005. Landings increased by 28% from 2,700 t in 2005 to 3,460 t in 2008, while effort declined by 48%.

Commercial CPUE (Table 4, Fig. 54) indicates that fishery performance has improved substantially in both inshore and offshore areas since 2005. Inshore CPUE has been consistently lower than offshore CPUE. Both offshore and inshore CPUE increased sharply from 2005 to record high levels in 2008.

Spatially, increases in CPUE occurred throughout the Division in 2008 (Fig. 55). The areas fished changed little from 1999-2003 (Dawe et al. 2004), and remained similar in 2004. In the inshore, there has been no clear change in spatial distribution of fishing effort in recent years, but in the offshore, since 2004, there has been a decline in effort in the St. Anthony Basin (extreme north portion of the division) as well as the extreme eastern part of the division (east of the Funk Island Bank) and along the slope edges.

The offshore fishery occurred progressively earlier from 2004 to 2006 (Fig. 56). However, in 2007 and 2008, the fishery was delayed with minimal effort occurring until week 6, by which time most of the 2006 fishery had occurred. These delays are attributable to unfavourable ice conditions in the spring of 2007 and 2008 off the northeast coast of Newfoundland. Despite this, the fishery progressed fairly rapidly in both years, with most of the total effort expended by week 11 in both years.

The inshore fishery, as in the offshore, occurred progressively earlier each year from 2004 to 2006 (Fig. 56b), but was delayed in 2007 due to severe spring ice conditions. In 2008, ice conditions were less of a factor and the fishery was underway by early May. The 2008 fishery was virtually finished by week 13, as it was in 2006 and 2007, but earlier than in 2004 and 2005. Total effort expenditure decreased from 2004 to 2007 and was unchanged in 2008 (Fig. 56b).

Effect of ocean climate variability

Divisional commercial CPUE (inshore and offshore combined) was inversely related to bottom temperature (at Station 27) and positively related to areal extent of the CIL at an eight year lag, since the early 1980's (Figs. 57-58). However, since 2005 CPUE has increased to a very high level while bottom temperature has remained high and the spatial extent of the CIL has been low. This substantial improvement in fishery performance is not entirely due to change in the exploitable biomass, but is also partly due to the reduction in fishery removals during 2005-07 (Fig. 53), a general trend toward earlier fishing seasons since 2003 to 2004 (Dawe et al 2009), and reduced fishing effort since 2004 (Fig. 53), which jointly resulted in reduced fishing mortality on exploitable crabs as well as soft-shelled pre-recruits.

DIVISION 3K OFFSHORE

Biomass

The commercial logbook, observer, and VMS CPUE indices all increased sharply from 2005 to 2007 (Fig. 59). However there was a disassociation in trend between the VMS index and the logbook and observer indices in 2008, with the VMS index decreasing while the other indices increased. The reasons for this disassociation in trends are unclear but could be related to changes in fishing practices affecting one or more of the indices (Mullowney and Dawe 2009).

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 60). The percentage of available 5' x 5' cells occupied by the fishery declined from its highest level of 48% in 2004 to its lowest level since 1995 in 2007, and was unchanged at 8% in 2008.

Commercial logbook CPUE has been higher throughout the season during the past two years than in 2004-06, with consistency in its trends with both weekly (Fig. 61a) and cumulative catch (Fig. 61b). Trends in VMS CPUE throughout the season (Fig. 62) agreed with logbook CPUE, indicating that CPUE was at a higher level throughout the season during the past two years than in 2004-06 according to its trends with both weekly (Fig. 62a) and cumulative catch (Fig. 62b).

Trends in the logbook-based mean catch rate from the STRAP analysis (Fig. 63) reflected raw logbook CPUE, increasing steadily since 2005. These trends were consistent in both the common strata (strata fished in all years) and all strata (all strata fished in a given year) analyses, indicating the increase in catch rates has occurred throughout offshore Div. 3K.

Size distributions from at-sea sampling by observers (Fig. 64) indicate that modal CW increased from 101 mm in 2001 to 110 mm in 2002, and has since remained at that size. Catch rate of most sizes of legal-sized older-shelled animals increased progressively from 2004 to 2007. The overall catch rate of legal-sized crabs in 2008 was similar to that in 2007, but the proportion of new-shelled animals was greater at most sizes. New-hard-shelled crab represented the highest proportion of legal-sized crabs sampled by observers in 2003 (Fig. 65a). Their catch rate decreased in 2004 and changed little until it increased in 2008 back to the 2003 level. Catch rates of legal-sized old-shelled crabs increased steadily from 2004 to their highest level in 2007, and remained high in 2008 (Fig. 65a). Observed catch rates of soft-shelled crab were at their lowest level in the time series in 2006-08, constituting a minimal portion of the catch. Trends in the catch rate of new-hard and old-shelled legal-sized crabs, when combined, have agreed well with observed CPUE since 2004 (Fig. 65b). As we noted for Div. 2J, it is unclear to what extent this reflects misclassification of some new-hard-shelled crabs (shell 2) as old-shelled (shell 3) crabs versus retention of some new-hard-shelled crabs by the fishery.

The exploitable biomass increased substantially in recent years and remains relatively high, as indicated by both post-season surveys. The post-season trawl survey exploitable biomass index (Table 13, Fig. 66) decreased from its highest level by almost half in 1999. It changed little until it decreased again from 2001 to its lowest level in 2003. It increased sharply from 2003-2007 to approach the highest level previously observed before decreasing slightly in 2008. The post-season trap survey exploitable biomass index increased sharply in 2006 (Fig. 66) and has since fluctuated while remaining higher than it was during 2004-05.

The industry-DFO collaborative post-season offshore trap survey catch rate of legal-sized crabs, from stations common to all years, varied without trend from 2004 to 2008 (Fig. 67). This limited time series of trap survey data did not reflect the recent trends in the exploitable biomass index from the post-season trawl survey (Fig. 66).

Production

Recruitment. Recruitment has increased in recent years, as reflected by the increase in exploitable biomass while landings increased. Also, the post-season trawl survey indicates that the component of the exploitable biomass that represents immediate recruits (new-shelled legal-sized crab) has increased steadily since 2004 (Fig. 68a). This suggests that recruitment will increase in 2009.

Trends in catch rate of legal-sized crab by shell condition from the industry-DFO collaborative trap survey (commercial mesh size, Fig. 67) varied without trend from 2004 to 2008. Size distributions from this survey (Fig. 69) showed an increase in modal size from 100 mm to about 110-112 mm during 2006-08, as they did previously during 2004-06. This suggests increased recruitment since 2004, consistent with the increase in catch rate of immediate pre-recruits from the fall multi-species trawl surveys.

A group of small adolescents that has been apparent in the fall multi-species size distributions during the past two years achieved a modal size of about 65 mm CW in 2007 (Figs. 70-71). These adolescents would not yet have achieved the minimum legal size, but most would be expected to contribute to the pre-recruit biomass index from the 2008 survey and should begin contributing to the exploitable biomass over the next few years. However, a substantial portion of these (and smaller) adolescents had terminally molted in 2008 (Fig. 70) to be new-shellled (Fig. 71) sub-legal-sized adults that did not contribute to the 2008 pre-recruit biomass index. Longer-term recruitment prospects are uncertain. However relatively low abundance of smallest males (<50 mm CW) in the surveys since 2003 (Figs. 70-71), together with the persistence of a warm oceanographic regime (Fig. 57) may suggest relatively poor recruitment prospects in the long term.

The observed catch rates of under-sized crabs closely matched the catch rates of total discards for the third consecutive year in 2008 (Fig. 72), implying that most of the discarded catch was comprised of under-sized crabs. This contrasts with 2004 and 2005 when catch rates were much higher for total discards than for under-sized crabs, which implied high prevalence of soft-shelled crabs. Catch rates of undersized crabs have been unchanged since 2002.

The fall survey pre-recruit index (Table 14, Fig. 73) declined from 1997 to its lowest level in 2003, and then increased sharply to 2006. It has since fluctuated and remains relatively high in 2008, despite the relatively high proportion of new-shelled under-sized adults (Fig. 70). The post-season trap survey catch rate of undersized crabs has fluctuated throughout its limited time series (Fig. 67). Recruitment remains promising for the next several years.

Reproduction. The percentage of mature females carrying full clutches of viable eggs (Fig. 74) varied at a high level from 1995 to 2004, exceeding 80% in all years but 1996. It fell to 61% in 2005 but has increased steadily to almost 100% in 2008.

Mortality

Exploitation. The trawl survey exploitation rate index has declined slightly over the past 3 years (Fig. 75). The high mortality indices for 2004 are likely due to anomalously low biomass indices from the 2003 survey (Fig. 66 and Fig. 73). The relatively low 2008 exploitation rate index is consistent with an increase in catch rate of old-shelled crabs from the post-season trap survey in 2008 (Fig. 67), but inconsistent with a decrease in catch rate of old-shelled crabs from the post-season trawl survey (Fig. 68). Despite this inconsistency, and associated uncertainty, the 2008 trawl survey biomass index remains relatively high (Fig. 66) due to increased recruitment (Fig. 68). Therefore, maintaining the current level of fishery removals would not likely substantially change the exploitation rate in 2009.

Indirect fishing mortality. The pre-recruit fishing mortality index (Fig. 75) decreased sharply in 2006 and has since changed little. The percentage of the total catch discarded in the fishery (Fig. 75) increased from 2002 to about 30% in 2005, reflecting increased wastage of under-sized and new-shelled pre-recruits. The high wastage in 2005 is consistent with a high incidence of soft-shelled pre-recruits in the catch, which resulted in a premature closure of the fishery and failure to achieve the TAC (Dawe et al. 2009). The percentage discarded decreased sharply in 2006 (Fig. 75) and continued to decline to its lowest value in 2008. This implies greatly reduced wastage of under-sized and soft-shelled pre-recruits in the fishery since 2005.

Overall, observed weekly levels of soft-shelled crab were relatively low in 2006 and 2007, not exceeding 20% in any week (Fig. 76). In 2008, weekly soft-shelled levels were low in most weeks, but exceeded 20% in weeks 11 and 14. The low percentages of soft-shell crabs in most weeks during 2006-08, are likely due, in part, to an increase in the exploitable biomass in recent years (Fig. 66). Regardless of the cause, this implies a decrease in wastage of soft-shelled crabs in the 2006-08 fisheries compared to the high levels in 2004 and 2005.

The fishery occurred earlier each year from 2004 to 2006 (Fig. 56), but was delayed in 2007 and (to a lesser extent) in 2008 due to spring ice conditions off northeast Newfoundland. The bulk of the 2006 effort occurred from weeks 3-6 whereas most of the 2007 and 2008 effort occurred from weeks 4-11. Soft-shelled crab catch rates gradually increased after week 7 in both of the past two years, likely reflecting seasonality in timing of molting. The weekly distribution of observed sets has been consistent with that of total fishing effort during the past five years (Fig. 77). Therefore weekly observations of soft-shelled crab levels likely reflect true prevalence in the fishery with little temporal bias.

The Funk Island Deep in the southern part of offshore Div. 3K (Fig. 55) was closed to gillnet fisheries in 2002 and has been closed to all fisheries except snow crab during 2005-08 (Fig. 78). It would be premature to draw any firm conclusions regarding the impact of this closure on the snow crab resource because the closure has been in place for 6 years whereas the period between settlement and recruitment is believed to be about 7 years (Dawe et al 2008). However, CPUE has increased both inside and outside of the closed area since 2005. While CPUE was much higher inside than outside the closed area in 2007 and 2008, this was also commonly the case prior to 2002 when no closure was in place.

Natural Mortality (BCD). Prevalence of BCD, from multi-species trawl samples (Fig. 79), has overall been higher in this division than in any other division, with maximum levels during 1996-98, and 2008, in the order of 8% in 40-75 mm CW new-shelled males. Annual trends in BCD prevalence (across all sizes) were similar to those in the survey biomass indices, especially for pre-recruits (Fig. 73), featuring highest values in 1996-98, a sharp drop to minimum levels in 1999, generally lower levels during 2000-07, and an increase in 2008. This implies a possible density-dependent effect on prevalence. The very low prevalence levels, across all sizes for both adolescents and adults in 1999 and 2003 (Fig. 79) coincides with anomalously low survey biomass indices, especially for pre-recruits (Fig. 73). If those anomalously low biomass indices are due to low trawl efficiency, as believed, then this implies that infected crabs have a higher catchability by the survey trawl than healthy crabs.

DIVISION 3K INSHORE

Biomass

The commercial logbook CPUE index increased steadily from 2005 to 2008 to exceed the highest level previously observed (Table 4, Fig. 80), following a decline during 2002-05. The observer CPUE index agreed with logbook CPUE, increasing sharply in 2007 and 2008 (Fig. 80). The observer CPUE index varied without trend from 2001 to 2006 and has consistently been higher than logbook CPUE. This could be attributable to spatial and temporal variability in annual observer coverage and low levels of coverage in this area.

The spatial coverage of the fishery has been inversely related to commercial CPUE in most years from 1996 to 2008 (Fig. 81). The area fished has decreased from about 40-45% of available cells occupied in 2004-05, to about 28-30% cells occupied in 2006-08. During this same period CPUE has increased steadily.

Trends in commercial CPUE throughout the season (Fig. 82) indicated that the early to mid-season CPUE was higher in 2008 than in the previous 4 years. The late-season weekly CPUEs in 2008 were at a comparable level to those of 2007, higher than in 2004-06 (Fig. 82a). However this comparison by week is biased in that the fishery was prosecuted much later in 2007 than in 2008 (Fig. 56).Trends in relation to cumulative catch (Fig. 82b), showed that the 2008 fishery outperformed the fisheries of the previous 4 years at all levels of removals.

Trends in the logbook-based mean catch rate from the STRAP analysis (Fig. 83) reflected raw logbook CPUE, increasing steadily since 2005. These trends were consistent in both the common strata (strata fished in all years) and all strata (all strata fished in a given year) analyses, indicating the increase in catch rates has occurred throughout the inshore fishing area in Div. 3K.

Size distributions from at-sea sampling by observers (Fig. 84) indicate that modal CW decreased from 95 mm in 2001 to below legal-size, at 89 mm, in 2003. Modal CW then increased to 101 mm CW in 2005 while catch rates of legal-sized soft and new-hard-shelled crabs increased (Fig. 85), indicating increasing abundance of immediate pre-recruits. Modal CW further increased to 110 mm in 2006-08, as catch rates of old-shelled crabs increased (Fig. 85), indicating increasing recruitment. These size frequencies indicate a large increase in the proportion of legal-sized old-shelled males in the catches in 2007 and 2008, consistent with the increase in recruitment which began in 2005.

The observed catch rates of legal-sized soft and new-hard-shelled crab decreased from 2005 to 2007 and remained low in 2008 (Fig. 85a), while the catch rates of old-shelled crab increased to their highest levels. In most years, the CPUE of all crabs kept exceeded that of old-shelled crabs to a much greater degree inshore (Fig. 85a) than was the case offshore (Fig. 65a). The extent to which this reflects a higher level of mis-classification of intermediate-shelled crabs as new-hard shelled versus a higher proportion of new-hard-shelled crabs in the retained catch, in inshore Div. 3K, is unknown. The catch rate of new-hard and old-shelled legal-sized crab, when combined, has exceeded the retained (kept) catch rate during 2004-06 (Fig. 85b) but agreed well in 2007 and 2008. Variability in this relationship is likely attributable to lower levels of observer coverage and spatial or temporal variation in sampling across years by observers in the inshore areas of Div. 3K.

The exploitable biomass increased substantially to 2006 and remains relatively high. The post-season trap survey exploitable biomass index increased from 2004 to 2006 and has since changed little (Fig. 86). Those surveys also showed that catch rates of older-shelled legal-sized crabs have increased since 2004 (Fig. 87).

Production

Recruitment. Recruitment has increased in recent years, as reflected by the increase in the post-season trap survey exploitable biomass index (Fig. 86) while fishery removals increased (Fig. 53). Abundance of new-shelled legal-sized crabs from the industry-DFO collaborative survey (Fig. 87) has remained higher than that of older-shelled legal-sized crabs from 2004 to 2008. Size distributions by shell condition from this survey (Fig. 88) have changed little over the past five years with a primary mode at 92-94 mm CW each year.

Data from the DFO inshore post-season trap survey (Fig. 89) indicate a high level of spatial variability in catch rates from both small-meshed (Fig. 90a) and large-meshed (Fig. 90b) traps. Recent catch rates of new-shelled (soft + new-hard) legal-sized males (immediate pre-recruits) generally peaked in 2003 due to high catch rates of soft-shelled crabs in particular. In White Bay, new-shelled crab catch rates subsequently declined while catch rates of old-shelled (intermediate + old) crabs increased to 2005 in stratum 614 and to 2006 in deeper stratum 613. Catch rates of new-shelled crabs increased in both those strata from 2007 to 2008, while catch rates of old-shelled crabs declined to very low levels. In Notre Dame Bay, catch rates of new-shelled crabs increased from 2005 to 2007 they changed little in stratum 611 but decreased sharply in deeper stratum 610 in 2008. The anomalously low catch rates in 2004 likely reflect reduced catchability by traps in that year. Catch rates of old-shelled crabs have increased steadily over the past 3-4 years in both Notre Dame Bay strata.

The catch rates of under-sized crabs in 2008 from observer at-sea sampling agreed with the catch rates of total discards for the second consecutive year (Fig. 91), implying that most of discarded catch was comprised of under-sized crabs. The much greater catch rate of total discards than of under-sized crabs during 2004-06, and particularly during 2005, reflects a high incidence of soft-shelled crabs in the catch. Catch rates of under-sized crabs declined from 2003 to their lowest level in 2006, and have since increased slightly.

Size frequencies from the inshore DFO trap surveys show much clearer trends in White Bay (Fig. 92) than in Notre Dame Bay (Fig. 93). A group of small adolescent males has been apparent in White Bay during the past four years (Fig. 92) that has not been apparent in Notre Dame Bay (Fig. 93). This group first appeared in 2005 in shallow stratum 615 at a modal size of about 50 mm CW, then in 2006 in deeper stratum 614 at slightly larger size, and subsequently in 2007 in deepest stratum 613 at a modal size of about 62 mm CW. The leading tail of this recruitment pulse began to achieve legal size in strata 614 and 613 in 2007-08 and should continue to contribute to the fishery in the short-term, but a large portion of this pulse appears to have terminally-molted to sub-legal-sized adults in stratum 615. In Notre Dame Bay (Fig. 93), there has been little change in size and shape of the distributions in shallow stratum 611 since 2003, with a high proportion of crabs terminally molting as sub-legal-sized crabs each year. In deeper stratum 610, there was little change in size structure from 2003 to 2007, excepting the anomalously low catch rates in 2004. However, in 2008 there appears to have been a decrease in numbers of sub-legal-sized crabs. The inability to detect clear trends in Notre Dame Bay may be due, in part, to a weakly structured physical domain relative to White Bay. Physical variables such as bathymetry and temperature are likely less important in regulating population structure and dynamics (ie. migrations) temporally and spatially in Notre Dame Bay than in White Bay.

Collaborative post-season trap survey catch rates of undersized crabs have changed little since 2004 (Fig. 94). However, this survey as well as the DFO post-season survey indicates different trends between the two bays that comprise the inshore area. Recruitment has recently decreased in Notre Dame Bay, whereas it is expected to increase in White Bay. Therefore, overall recruitment prospects are uncertain.

Mortality

Exploitation. The trap survey-based exploitation rate index (Fig. 95) changed little since 2005. Data are insufficient to estimate pre-recruit mortality rates. Maintaining the current level of fishery removals would not likely substantially change the exploitation rate in 2009.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 96) decreased sharply to the lowest level in the time series from 2005 to 2007 and was unchanged in 2008, implying little wastage of under-sized and new-shelled pre-recruits in the 2008 fishery. The high wastage in 2004-05 is consistent with a high incidence of soft-shelled pre-recruits in the catch. In 2005, this resulted in a premature closure of the fishery and failure to achieve the TAC (Dawe et al. 2008). The percentage of the catch discarded declined sharply in 2006 and 2007 to its lowest level in 2007-08, implying a low level of wastage in the 2007 and 2008 fisheries.

Overall, observed weekly levels of soft-shelled crab (Fig. 97) have decreased each year since 2004 with little exception. Seasonal peak incidence of soft-shelled crab by week has been variable since 2004. In 2008, the percentage of soft-shell in the catch was low in most weeks, but approached 20% in weeks 10 and 11 of the fishery. The low levels of soft-shelled crab in 2007 and 2008 were likely due to increased abundance of large older-shelled crabs (Fig. 85) and resultant decreased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies a decrease in wastage of soft-shelled crabs in the 2007 fishery.

The fishery occurred earlier each year from 2003-2006, but was delayed in 2007 (Fig. 98) due to severe spring ice conditions off northeast Newfoundland. The 2008 fishery began relatively early, by early May, similar to that of 2006. Most of the 2007 effort was intensely expended from weeks 9-13 whereas the 2008 weekly effort was more evenly distributed from about weeks 4-14. Soft-shell crab catch rates remained at relatively low levels in all but weeks 9 and 10 in 2008, when they comprised nearly 20% of the catch. The weekly distribution of observed sets agreed fairly well with that of total fishing effort in 2007 and 2008 (Fig. 98). Therefore the observed low levels of soft-shelled crab in the 2007 and 2008 fisheries are likely reliable.

Natural Mortality (BCD). Prevalence of BCD, from inshore post-season trap_surveys has been periodic (Fig. 99). BCD was initially detected in the post-season trap survey in 1995, and increased sharply to a peak of 13% in new-shelled males in 1996. Prevalence levels remained above 8% in 1997-98 but declined sharply in 1999 and 2000 (no survey in 2001) to a low of 2% in new-shelled males in 2002. Prevalence once again increased sharply from 2002 to 2006, with a peak of 17% in 2006. Overall prevalence remained high, but decreased slightly in 2007, before a sharp decline to 9% in 2008. Peaks in prevalence in Notre Dame Bay have preceded peaks in prevalence in White Bay by 1-2 years (Fig. 99). Similarly, peaks in prevalence in the shallowest stratum of White Bay have preceded peaks at successively deeper strata by 1-2 years, similar to the trend observed in catch rates of small adolescents (Fig. 92). In contrast, spatial or temporal lag effects have not been apparent between depth strata in Notre Dame Bay (Fig. 99). These spatial and temporal lags in prevalence between bays and depth strata could be attributable to annual changes in abundance (density dependence), migration, or oceanographic regime, such as circulation effects which may influence distribution of the parasite.

The BCD has consistently occurred at much higher prevalence levels in these inshore Div. 3K trap survey samples (Figs. 92-93) than in the predominately offshore Div. 3K Campelen trawl samples (Figs. 70-71). This likely reflects differences in catchability of diseased animals between traps and trawls (based on comparative trap/trawl sampling), but it may also, in part reflect higher prevalence in inshore than offshore areas.

In White Bay during 1995-99 there was a clear progression of BCD to successively larger crabs and successively greater depths (Fig. 100), such that about 50% of legal-sized new-shelled adolescents in the deepest stratum were infected in 1999. This progression with size and depth until 1999 reflects both the observed size-related depth distribution pattern (Dawe and Colbourne 2002), as well as increasing recruitment over that time period. Prevalence in White Bay (Fig. 100) increased in 2004 in small new-shelled males within the shallowest stratum and subsequently increased in progressively larger crabs in this stratum from 2005 to 2007 (Fig. 100). Prevalence levels remained similar in most sizes of adolescents during 2005 to 2008 in this stratum but have decreased for most sizes of adult crabs since 2005. BCD prevalence also increased greatly in all sizes of adolescent males in the intermediate-depth White Bay stratum in 2005 and remained high during 2006-08, with about 30% of the largest new-shelled adolescents infected in 2008. BCD prevalence increased sharply in the deepest stratum in smallest males in 2007, and in largest males in 2008.

In Notre Dame Bay (Fig. 101), prevalence (especially in adolescents) in the shallower stratum shifted from being highest in smallest males (40-75 mm CW) in 1995 to being highest in largest (legal-sized) males in 1998 and 1999. This trend was later repeated with prevalence shifting from being highest in smallest males in 2003-04 to being highest in largest males in 2006-07. Such trends were less clear in deeper stratum 610, where prevalence has recently remained high, exceeding 40% in smallest new-shelled adolescent males since 2006.

DIVISION 3L

The Fishery

Offshore landings (Table 5, Fig. 102) have generally been higher than inshore landings by a factor of 3 in recent years. Offshore landings peaked at 21,700 t in 1999 and decreased to 18,700 t in 2000 due to a reduction in TAC. Landings have averaged about 20,000 t since 2000. They decreased by 6% from 20,140 t in 2007 to 18,990 t in 2008. Effort has increased steadily since 2000 to its highest level in 2008. Inshore landings (Table 5, Fig. 102) peaked in 1996 at 7,920 t. They declined to 4,730 t in 2000, increased to 6,810 t in 2003, and decreased slightly to 6,110 t in 2005 due to changes in the TAC. Landings increased by 12% from 6,110 t in 2005 to 6,830 t in 2008, while effort decreased by 23%.

Commercial CPUE (Fig. 103) indicates that fishery performance has deteriorated offshore but improved inshore in recent years. Inshore CPUE was higher than offshore CPUE for the first time in 2008. Offshore CPUE has declined steadily from 2000 to 2008, to the lowest level since 1991. Inshore CPUE increased by 53% from 2004 to 2008. There has been little change in the spatial distribution of fishing effort in recent years (Fig. 104).

The 2008 offshore fishery developed later than in the previous two years, with little effort expended during the first 5 weeks of the season (Fig. 105a).It then progressed rapidly, as in 2007, lasting18 weeks, with virtually all effort expended by week 18, as in previous years. The level of recorded effort steadily increased from 2004 to 2007 and was unchanged in 2008. In 2004, about 1,300,000 trap hauls were recorded, while there were about 1,600,000 recorded trap hauls in 2007 and 2008.

The 2004 and 2005 inshore fishery commenced in May (weeks 5-8 following April 1), and ended in week 24 (Fig. 105b). However, in 2006 the fishery started in the second week of April, six weeks earlier than in 2005, and ended in week 20, a month earlier than in 2003-05. The 2007 and 2008 fisheries were delayed due to unfavourable ice conditions in the spring along the east coast of Newfoundland. Despite these delays, the fisheries progressed fairly rapidly with most of the effort expended by weeks 14-16 in both years, 1-2 months earlier than in previous years. Effort expenditure, as recorded in logbooks, has declined in recent years, from about 700,000 trap hauls in 2004 to 550,000 trap hauls in 2008 (Fig. 105b). The reasons for the anomously low level of recorded trap hauls in 2007 are unknown.

Effect of ocean climate variation

Bottom temperature in Div. 3L, has been inversely related to the divisional commercial CPUE at an eight year lag since the early 1970's (Fig. 106). In recent years, divisional CPUE has declined since 2000, while the lagged bottom temperature has increased to a high level. The spatial extent of the cold intermediate layer on the Grand Bank has been positively related to commercial CPUE, at an eight year lag, since the early 1970's (Fig. 107). Both indices have declined steadily since 2001-02.

DIVISION 3L OFFSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 108) have both decreased steadily from 2002 to 2008, to their lowest levels since 1991 (Fig. 103). VMS-based CPUE (Fig. 108) decreased gradually from 2004 to 2006, was unchanged in 2007, and decreased sharply in 2008.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1995 (Fig. 109). The percentage of available 5' x 5' cells occupied by the fishery reached it highest level, of 35%, in 2008, while CPUE declined to its lowest level in the time series. Annual changes in the extent of spatial coverage of the Div. 3L offshore fishery are less abrupt than in other Divisions. The Div. 3L offshore fishery primarily occurs along the broad slope of the northern portion of the Grand Bank (Fig. 104), whereas in other divisions effort more commonly occurs at greater depths. Bathymetric and habitat (eg. muddy substrate) limitations in offshore Div. 3L may account for the limited annual variation in fishing effort distribution since 1999.

Trends in commercial logbook CPUE throughout the season (Fig. 110) indicate that CPUE was generally lower throughout the season in 2007 and 2008 than it was during the previous 3 years, especially until week 9 (Fig. 110a) up to a cumulative catch of about 8,000 - 10,000 t (Fig. 110b). The trend in relation to cumulative catch (Fig. 110 b) shows that late-season CPUE (at about 10,000-15,000 t cumulative catch) was clearly lowest in 2008. Seasonal VMS-based CPUE trends throughout the season since 2004 (Fig. 111) showed that late-season CPUE was lower in 2008 than in the previous 4 years, according to trends in relation to both week (Fig. 111a) and cumulative catch (Fig. 111b). After week 7, or about 6,000 t of landings, 2008 catch rates dropped sharply, and mid to late-season catch rates were the lowest since 2004.

Trends in the logbook-based mean catch rate from the STRAP analysis (Fig. 112) reflected raw logbook CPUE, declining steadily since 2002. These trends were consistent in both the common strata (strata fished in all years) and all strata (all strata fished in a given year) analyses, indicating the decrease in catch rates has occurred throughout offshore Div. 3L.

Size distributions from at-sea sampling by observers (Fig. 113) became increasingly platykurtic from 2002 to 2007. However, in 2008, a distict mode developed due to an increase in the proportion of small (≤ 98 mm CW) males in the population. Modal CW had increased from 104 mm in 2001 to 110 mm in 2005-07 as catch rates of most size groups decreased, suggesting low levels of recruitment into the fishery. The increased proportions of small legal-sized males in 2008 suggest increased recruitment in 2008, and the mode at 92 mm CW suggests further recruitment into the fishery in the near future.

Observed catch rates of new-shelled legal-sized crabs declined from 2001 to 2005 and have since remained unchanged, whereas catch rates of legal-sized old-shelled crabs have declined steadily since 2002 (Fig. 114a). Catch rates of old-shelled crabs have consistently been higher than those of new hard-shelled crabs, and catch rates of soft-shelled crabs have been consistently low (Fig. 114a). Trends in the levels of new-shelled and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the observed CPUE throughout the time series, better than in Div. 2J (Fig. 38) or Div. 3K offshore (Fig. 65). This agreement, in offshore Div. 3L has been particularly tight since 2004 (Fig. 114b), as we also noted for offshore Div. 3K (Fig. 65b). Trends in the exploitable biomass are uncertain but levels remain low. The trawl survey exploitable biomass index declined sharply from 1996-2000 and changed little to 2005 (Table 15, Fig. 115). The exploitable biomass index declined sharply in both post-season surveys in 2006. It has since remained low in the trap survey but has increased in the trawl survey over the past two years.

Production

*Recruitment.*_ Recruitment has recently increased. The post-season trap (Fig. 116) and trawl surveys (Fig. 117) indicate that the component of the exploitable biomass that represents immediate recruits (new-shelled legal-sized crab) has increased since 2006. This suggests that recruitment will increase in 2009. Annual changes in the fall multi-species trawl survey biomass index by shell condition (Fig. 117a) reflected greater internal consistency than was evident in Div. 3K. Biomass of new-shelled legal-sized males declined from 1996-99, whereas intermediate-shelled legal-sized males declined later, from 1998-2000, and old-shelled crabs declined later again, from 1999-2001. Biomass of all shell categories generally declined subsequently to record low levels in 2006. The biomass of new-shelled legal-sized crabs increased greatly in 2007-08 while biomass of all other categories remained very low (Fig. 117a). The increase in percentage of the survey legal-sized catch that was new-shelled (Fig. 117b) implies an increased dependence of the exploitable biomass on recruitment.

Trends in catch rates of legal sized crabs by shell condition from the collaborative post-season trap survey agreed with those from the post-season trawl survey. Catch rates of old-shelled legal-sized crabs from the trap survey (Fig. 116) declined sharply by about two-thirds from 2005 to 2008, reflecting persistent low recruitment in recent years, while catch rates of new-shelled legal-sized crabs have gradually increased. Size distributions from this trap survey showed a substantial decrease in catch rates of legal-sized new-shelled crab in 2005 with little change to 2007 (Fig. 118). However, in 2008 catch rates of new-shelled crabs increased across the entire size range, particularly in small legal-sized (95-100 mm CW) and sub-legal-sized (80-94 mm CW) males.

Size distributions from the fall multi-species trawl survey show the presence of a group of small adolescents in recent years that achieved a modal size of about 77-80 mm CW in 2007 (Fig. 119) and appeared to increase in abundance in 2008. These adolescents began to recruit to the legal sized population as new-shelled crabs in 2008 (Fig. 120) and should contribute further to the exploitable biomass in the next 2-3 years.

Trends in the observed catch rate of under-sized crabs have generally agreed with that of total discards since 2004, with a particularly tight association in the past two years as catch rates of undersized crabs increased (Fig. 121). This implies that discards have consisted virtually entirely of undersized crabs in recent years. This contrasts earlier years, especially 2001 (Fig. 121) when undersized crabs did not represent most of the discards, implying that soft-shelled crabs represented a more important component of the discards than they have in recent years.

Both post-season surveys indicate that recruitment has been increasing and is expected to increase further over the next two to three years. The post-season trawl survey pre-recruit index (Table 16, Fig. 122) and the post-season trap survey catch rate of under-sized crabs (Fig. 116) have both increased sharply since 2006. The 2008 trawl survey index was the highest since 1996 (Fig. 122).

Reproduction. The percentage of mature females carrying full clutches of viable eggs (Fig. 123) declined from 100% in 1995 to about 50% in 2001. Since 2002, the level has varied between 80-97%, with about 92% of females carrying full clutches in 2008.

Mortality

Exploitation. The exploitation rate index (Fig. 124) and pre-recruit fishing mortality index (Fig. 124) both increased to their highest levels in 2007. The exploitation rate index remained at a high level in 2008 while the pre-recruit fishing mortality rate index decreased to about the long-term average. The sharp increases in these indices in 2007 were due to decreases in the survey exploitable biomass index (Fig. 115) and pre-recruit biomass index (Fig. 122) in 2006. The ratio of pre-recruits to exploitable crab is expected to increase to a high level due to the low biomass and increasing recruitment. This could pose a risk of high fishery-induced mortality to soft-shelled immediate pre-recruits in 2009.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 124) increased sharply in 2008 from a low level during 2004-07. This implies an increase in wastage of under-sized and new-shelled pre-recruits in the fishery in 2008.

The prevalence of soft-shelled crab in the catch throughout the season (Fig. 125) was lower in offshore Div. 3L than it was in Div. 2J (Fig. 49) or offshore 3K (Fig. 76). The weekly percentage of soft-shelled crab in 2008 gradually increased as the season progressed but remained low throughout the fishing season, as in previous years. Soft-shell crab comprised ≤10% of the catch in all weeks of the 2008 fishing season.

The fishery started earlier in 2006-08 than in previous years (Fig. 126), as was also true for offshore Div. 3K (Fig. 77). However the offshore Div. 3L fishing season has remained much more prolonged, spanning 17-19 weeks in totality each year from 2006 to 2008 (Fig. 126). Despite the prolonged offshore Div. 3L fishing seasons, soft-shelled crab catch rates have remained at low levels in all weeks in all years (Fig. 126). The weekly distribution of observed sets has agreed well with that of total fishing effort since 2005 (Fig. 126). In 2008, 83% of the observed sets occurred from weeks 6-16. There is increased confidence that weekly observations of soft-shelled crab reflect true prevalence in the fishery when the distribution of observed sets agrees well with that of total fishing effort such as in Div. 3L offshore since 2005.

Natural Mortality (BCD). BCD generally occurs at lower levels in Div. 3L than in Div. 3K. Prevalence (in new-shelled males) from offshore Div. 3L fall multi-species trawl surveys (Fig. 127) has been variable with highest incidence during 2003-05. Prevalence of infection decreased considerably in 2006, and was non-existent in most groups of crabs in 2007-08. Maximum prevalence was during 2004, at about 8% in 40-59 mm CW adolescents and 14% in 60-75 mm CW adults.

DIVISION 3L INSHORE

Biomass

Logbook and observer CPUE indices (Fig. 128) trended together from 2002 to 2006. Both indices showed a decline in catch rates from 2002 to 2004, with a subsequent increase in 2006. However, the trends opposed one another in 2007 as logbook CPUE increased while observer CPUE decreased, and the level of the two indices agreed for the first time. In 2008, the indices again agreed, with both increasing to about 12 kg./ trap. The reasons for the disagreement in scale in earlier years are unclear, but there has been no such disparity between indices in the past two years.

There has been no clear opposing trend in spatial distribution of the fishery relative to commercial CPUE as seen in most other divisions. Rather, the areal extent of the fishery consists of two distinct levels, with about 30-45% of available 5' x 5' cells occupied each year from 1995-2001 and about 70-80% of cells occupied each year thereafter. This is attributable to localized spatial expansion of effort throughout the inshore of Div. 3L beginning in 2002 which was most pronounced in coastal regions of the Northeast Avalon and the western half of Conception Bay (Dawe et al. 2003). The sharp increase in spatial coverage of the fishery in 2002 was followed one year later by a sharp decline in CPUE. CPUE has increased since 2004, with the 10-12 kg./trap catch rates in 2007-08 approximating the pre-2002 level.

Trends in commercial CPUE throughout the season (Fig. 130) indicated that CPUE was generally higher throughout the season in 2008 than in the previous 4 years . In most years, there was a pattern of seasonal depletion across weeks, with an increase in CPUE in the mid-portions of the season, from weeks 7-11 (Fig. 130a). Only in 2005 was steady depletion evident throughout the season (Fig. 130b). The late-season CPUE, at cumulative removal levels of 3000 t or greater, has increased each year since 2005 (Fig. 130b).

Trends in the logbook-based mean catch rate from the STRAP analysis (Fig. 131) reflected raw logbook CPUE, increasing since 2004. These trends were consistent in both the common strata (strata fished in all years) and all strata (all strata fished in a given year) analyses, indicating the increase in catch rates has occurred throughout most of the inshore in Div. 3L.

Size distributions from at-sea sampling by observers (Fig. 132) changed very little between 2002 and 2005 with modes at 92 and 98-101 mm CW. Recent trends in size structure are similar to those we described from the offshore fishery (Fig. 113). The size distributions became platykurtic during 2006-07 due to declining catch rates of small (<107 mm CW) crabs (Fig. 132). In 2008, the distribution became positively skewed, as catch rates of sub-legal and small legal-sized (92-98 mm CW) crabs increased.

The catch rates of legal-sized old-shelled crab in the fishery have decreased since 2000 (Fig. 133a) while the catch rates of legal-sized new-shelled crab have varied at 5-8 kg/trap since 2002. Observed levels of soft-shelled crab have remained low throughout the time series. Trends in the catch rates of intermediate and old-shelled legal-sized crab, when combined (exploitable crabs), reflected the observed CPUE in most years from 1999-2007 (Fig. 133b). However, in 2008 the trends opposed one another, as overall CPUE increased while catch rates of exploitable crabs decreased. The reasons for this divergence are unclear, and inconsistent with other areas, where agreement between these indices has been particularly close in recent years, as was the case in this area from 2005 to 2007 (Fig. 133b).

The exploitable biomass has recently increased. The post-season trap survey exploitable biomass index (Fig. 134) indicates the exploitable biomass increased from 2004 to 2006 and changed little since.

Production

Recruitment. Recruitment had increased in recent years, as reflected by the increase in the post-season trap survey exploitable biomass index while fishery removals increased. However, the post-season collaborative trap survey catch rate of legal-sized new-shelled crabs decreased in 2008 (Fig. 135), suggesting decreased recruitment. This survey and localized DFO trap surveys in two bays indicate that there is considerable spatial variability in recent recruitment.

Size distributions by shell condition from the post-season collaborative trap survey (Fig. 136) have changed little over the past five years with a primary mode increasing slightly from 94 to 96 mm CW from 2005 to 2008. Data from small-mesh traps in inshore DFO trap surveys in Bonavista and Conception Bays (Fig. 137) show increased catch rates of legal-sized new-shelled males from 2000 to 2005 in both areas (Fig. 137a). In summer, in Bonavista Bay, catch rates of new-shelled legal-sized males declined from 2005 to 2008 whereas catch rates of old-shelled legal-sized males increased from 2005 to 2007 before decreasing in 2008. Intermediate and old-shelled crab represented the greatest proportions of catches from 1996-2000 but from 2001 to 2005 soft and new hard-shelled crabs were most common. The percentage of intermediate-shelled crabs in the catch increased in 2006 and 2007, and the percentage of old-shelled crabs increased in 2008. In fall, in Conception Bay, the catch rate of new-shelled legal-sized males changed little at a relatively high level from 2002 to 2005 before increasing sharply in 2006 to the highest level in the time series. It decreased in 2007 and changed little in 2008. The sharp increase in 2006 was associated with a sharp increase in catch rates of old-shelled legal-sized crab one year later, in 2007, from the low 2003-06 level. Similarly, the decrease in new-shelled legal-sized crabs in 2007 was followed by a decrease in catch rate of old-shelled crabs in 2008. The percentage of intermediate and old-shelled crab in the catch decreased from 1999-2006 but increased in 2007 and changed little in 2008. Trends in catch rates and composition by shell condition from large-meshed traps (Fig. 137b) closely reflect those from the small-meshed traps in both bays.

The observed catch rate of under-sized crabs in inshore Div. 3L closely matched the catch rate of total discards since 2006 (Fig. 138), implying that most of the discarded catch was comprised of under-sized crabs in recent years. This contrasts with 2005 when catch rates of under-sized crabs were much lower than that of total discards, implying a higher proportion of soft-shelled crabs in the discards in 2005. Trends in these two indices have generally agreed since 2001. The catch rates of under-sized crabs declined sharply in 2002 and continued to decline gradually to its lowest level in 2007, before a sharp increase in 2008. This increase in 2008 predominately reflects increasing recruitment prospects in Trinity Bay, as the most of the observer coverage was directed at this bay in 2008.

Male size distributions from the DFO inshore trap surveys (Fig. 139) show considerable year-to-year changes in small-meshed trap catch rates across a broad size range for both adolescents and adults. For example there was a large increase in catch rates across a broad size range in Conception Bay in 2004, and, to a lesser extent, in Bonavista Bay in 2006. These increases were followed by decreases the following year, indicating changes in catchability by traps. Despite this effect, a group of pre-recruit adolescents had been evident in Conception Bay since 2004, maintaining recent recruitment. However, these adolescents were virtually non-existent in 2008 with most of both legal and sub-legal-sized crabs comprised of adults. In Bonavista Bay, there has been no strong signal of pre-recruit adolescent crabs since 2004. This suggests relatively poor recruitment prospects in Conception and Bonavista bays in the near future.

Recruitment prospects are uncertain. The post-season collaborative trap survey data show no recent change in catch rates of sub-legal sized crabs (Fig. 140). This, in part, reflects differing trends in recruitment among inshore Div. 3L CMAs.

Mortality

Exploitation. The trap survey-based exploitation rate index changed little since 2005 (Fig. 141). Maintaining the current level of fishery removals would not likely substantially change the exploitation rate in 2009. Data are insufficient to estimate pre-recruit mortality rates.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 142) increased in 2008 to about the long-term average implying increased wastage of under-sized and new-shelled pre-recruits in the 2008 fishery. However, this index is biased by a change in spatial distribution of observer sampling in 2008.

Overall, observed weekly levels of soft-shelled crab were low in 2008, comparable to the levels observed from 2005 to 2007 in most weeks (Fig. 133). The percentage of soft-shell in the catch remained low until week 16, the last week of the fishery, when it reached 20%. In all years, soft-shelled crab has consistently constituted only a minor portion of the catch in the early to mid portions of the season in Div. 3L inshore, but prevalence levels tend to increase in the latter part of the season.

The fishery has started earlier in the past three years than it had in preceding years (Fig. 144). In 2006, 47% of the effort had been expended by week 7, the point at which the 2005 fishery started. The 2007 and 2008 fisheries were delayed in starting relative to 2006, attributable to spring ice conditions. Despite this, the seasons progressed fairly rapidly with the bulk of effort expended by week 14 in both years. The weekly distribution of observed sets relative to fishing effort has been proportional to the distribution of total fishing effort since 2004 (Fig. 144), allowing for confidence that the observed percentage of soft-shelled crabs in observer samples reflects that in the fishery.

Natural Mortality (BCD). The trend in prevalence of BCD from Conception Bay trap surveys (Fig. 145) was somewhat similar to that from the multi-species trawl surveys throughout offshore Div. 3L (Fig. 127), but at higher levels of prevalence, with highest prevalence during 2004-05. Trends in prevalence of BCD in trawl surveys in Conception Bay have been similar to those in the trap surveys, but at lower levels. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2003-05 before decreasing to 2007 and remaining low in 2008. Prevalence in 2008 was at it's lowest level since 2003 in all sizes of crabs, excepting an anomalously high level in 60-75 mm CW adolescents from traps.

DIVISION 3NO

The Fishery

The fishery began in the mid-1980's in Division 3O and expanded along the shelf edge in 1999. It has since been concentrated along the shelf edge, and mostly in Div. 3N. Landings increased by 22% from 3,600 t in 2005 to 4,400 t in 2008 while effort increased by 57%, to an all-time high in 2008 (Table 6, Fig. 146).

Commercial CPUE (Fig. 147) has declined since 2002, to its lowest level in 2008. The spatial distribution of fishing effort and CPUE has changed in recent years. For example there has been a reduction of effort in Div. 3O since 2004 and an increase in effort along the southern 3N slope in 2007-08 (Fig. 148).

The 2006-08 fisheries started 2-5 weeks earlier than in the 2 previous years (Fig. 149). This earlier start to the fishery has resulted in prolonged seasons in recent years, as the earlier start has not been associated with earlier completion. The total recorded effort increased from about 275,000 trap hauls in 2006 to about 350,000 trap hauls in 2007-08; comparable to the 2004-05 level (Fig. 149).

Biomass

The commercial logbook, observer, and VMS CPUE indices were all at their lowest levels in 2008 (Fig. 150). Commercial logbook CPUE increased gradually from 1996-99 and remained unchanged until 2003. It then declined abruptly in 2004, was unchanged until 2006, but has since declined further during the past two years. Trends in the VMS-based CPUE have agreed with commercial CPUE since 2004. Similarly, observer CPUE declined gradually from 2002 to 2004, was unchanged until 2006, but has declined further during the past two years.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 2002 (Fig. 151). The absence of such a trend prior to 2002 is likely attributable to a period of spatial expansion in the fishery in a region with little available snow crab habitat. The percentage of available 5' x 5' cells occupied by the fishery increased sharply from 3.5% in 1998 to 11.4% in 1999. It has since fluctuated between 7-10% in any given year, with 10% of the available cells fished in 2008.

Trends in commercial logbook CPUE throughout the season (Fig. 152) showed that catch rates were lower throughout the season in 2007 and 2008 than in the previous 3 years (Fig. 152a). Catch rates in relation to cumulative catches (Fig. 152b) were at their lowest levels in 2008. Trends in seasonal VMS-based CPUE (Fig. 153) have generally exhibited more variability than did the logbook based-CPUE in relation to both weekly (Fig. 153a) and cumulative catches (Fig. 153b), but generally agreed that CPUE was lower throughout the season in 2007 and 2008 than in the previous 3 years.

In contrast to other divisions, CPUE trends from the STRAP analysis did not agree between the 'all strata' and 'common strata' analysis (Fig. 154). These indices diverged in recent years, especially during 2003-07. This divergence coincides with changes in the area fished described earlier (Fig. 148), which resulted in a decrease in fishing effort in 'common strata' and an increase in effort in 'all strata'. The divergence implies that fishery performance in new areas fished in recent years (along the slope) was inferior to that in traditional areas. Both CPUE indices from the STRAP analysis (Fig. 154) were inconsistent with raw logbook CPUE, as neither the 'all strata' nor 'common strata' analysis indicated a substantial decline in catch rate since 2002, as was evident in the raw logbook index (Fig. 147). The specific reasons for this disagreement are unknown, but it likely relates to temporal and spatial variation in catch rates in Div. 3NO. For example, catch rates in the Whale Deep and Haddock Channel areas of Div. 3O have increased since 2004 (Fig. 148), whereas those along the slope edge have declined (Fig. 148). As the STRAP-based CPUE is spatially weighted, and the survey strata in the Whale Deep and Haddock Channel are larger than those along the slope edge, this may have resulted in an inflation of the STRAP-based index relative to the raw logbook index in recent years.

Size distributions from observer sampling in Div. 3NO (Fig. 155) showed a gradual increase in modal CW from 110 mm CW in 2000-01 to 113 mm in 2003. Observed catch rates of most sizes decreased from 2002 to 2004 with a reduction in abundance of old-shelled crabs in the catch, before increasing in 2005-06, due to an increase in old-shelled crabs. The size distributions changed very little from 2005 to 2006, with modal CW at 100 mm, but became platykurtic in 2007, with decreases in catch rates of new and old-shelled crabs across a broad size range between 101-125 mm CW. In 2008, catch rates of most sizes decreased further, particularly at largest sizes, but there was a large increase in catch rates of small legal-sized new-shelled crabs (95-101 mm CW), similar to the increase observed in Div. 3L (Fig. 113). This indicates an improvement in recruitment prospects.

Old-shelled crabs have represented the highest proportion of legal-sized crabs sampled by observers since 2005 (Fig. 156a), but have steadily declined during the past two years. Catch rates of new hard-shelled crab gradually decreased from 1999, to their lowest level in 2007, but increased in 2008 due to the increased catch rates of small legal-sized crabs. Soft-shelled crabs have constituted a small portion of the catch throughout the time series. Trends in the catch rates of new hard-shelled and old-shelled legal-sized crab, when combined (exploitable crabs), have generally reflected the retained catch since 2003 (Fig. 156b).

Trends in the exploitable biomass are uncertain as survey indices (Table 17, Fig. 157) are unreliable. This is due to limited sampling of the resource which is concentrated in a small proportion of the survey area. Similarly, the collaborative post-season trap survey has been limited to a few isolated areas of Div. 3O (Fig. 3), and catch rates of legal-sized crabs from this survey (Fig. 158) have varied without trend since 2004.

Production

Recruitment. Recruitment has been increasing, as reflected by the increase in catch rate of small legal-sized new-shelled crabs from observer sampling during the 2008 fishery (Fig. 158), and is expected to increase further over the next two to three years. High annual variability in the exploitable biomass index (Fig. 157) and catch composition (Fig. 159) by shell condition reflect uncertainty in trends from the trawl survey in this area. However, a group of adolescents is apparent in the trawl survey size distribution (Figs. 160-161), as also seen in Div. 3L (Figs. 119-120), which should result in continued increasing recruitment for the next two to three years. This is consistent with an increase in catch rates of undersized crabs from observer data in 2008 (Fig. 162).

Catch rates of discarded crabs have closely agreed with catch rates of under-sized crabs since 2002 (Fig. 162), suggesting low incidence of soft-shelled crab in the Div. 3NO fishery in recent years.

The fall survey pre-recruit index (Table 18, Fig. 163) peaked in 1998, declined to 2005, and has gradually increased each year since. There is high uncertainty in interpreting trends for this area, as noted for the exploitable biomass, but the recent increasing trends are consistent with those from observer data (Fig. 162).

Reproduction. There was no clear trend in the percentage of females carrying full clutches of viable eggs in Div 3NO (Fig. 164). Almost all females carried full clutches in 1995-96 before declining to about 70% in 1999 and returning to 100% in 2001. It again declined to about 70% in 2005 before increasing to almost 100% in 2006. About 90% of captured mature females carried full clutches in 2007 and 2008.

Mortality

Exploitation. Trends in fishery-induced mortality are unknown. The exploitation rate and pre-recruit fishing mortality indices are not informative because of uncertainties associated with the survey biomass indices. The abundance of pre-recruits is expected to increase in 2009. This could pose a risk of high fishery-induced mortality to soft-shelled immediate pre-recruits in 2009.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 165) increased sharply in 2008, implying increased wastage of pre-recruits in the fishery.

The observed weekly prevalence of soft-shelled crab (Fig. 166) has been consistently low in Div. 3NO, but late-season levels have increased slightly in the past three years. In 2006, maximum weekly soft-shelled crab prevalence throughout the season never exceeded 20% but was at about 15% for two weeks late in the season (weeks 16 and 18). In 2007, prevalence peaked at 14% in week 14, and in 2008 soft-shell levels reached 20% for the first time in Div. 3NO, in week 17, the last week of the fishery.

The seasonal fishing pattern (Fig. 167) was similar to that in offshore Div. 3L (Fig. 126), in that fishery started earlier and was more prolonged during 2006-08 (Fig. 135) than in previous years. The Div. 3NO fishery spanned 18-19 weeks during 2006-08. Despite the prolonged fishing season, soft-shelled crab catch rates have remained at low levels in all weeks in all years. Most of the 2008 fishery occurred uniformly in weeks 3 through 17, with 94% of the trap hauls in this period. The weekly distribution of observed sets has agreed well with that of total fishing effort since 2004, but especially in recent years.

Natural Mortality; BCD. Bitter crab disease has been virtually absent from Div. 3NO, based on fall multi-species survey trawl samples.

SUBDIVISION 3Ps

The Fishery

The fishery began in 1985 and was limited to the inshore until the early 1990's. Landings (Table 7, Fig. 168) from offshore areas have been about twice as high as those from inshore areas in recent years. Landings from both offshore and inshore areas were at their highest level during 1999-2002. Offshore landings (Fig. 168) increased by 35% from 2,340 t in 2006 to 3,180 t in 2008, following a 46% decline from 2002 to 2006. Offshore effort increased by 19% in 2007 and decreased by 25% in 2008 to its lowest level since 2001 (Fig. 168). Inshore landings (Fig. 168) doubled from 660 t in 2005 to 1,350 t in 2008, following an 80% decline since 2002. Meanwhile, inshore effort changed little since 2005 until it decreased by 22% in 2008 (Fig. 168).

Commercial CPUE (Table 7, Fig. 169) has consistently been higher offshore than inshore. Offshore CPUE increased by 48% in 2008 but remains below the long-term average (Fig. 169). Inshore CPUE more than doubled since 2005 to the long-term average (Fig. 169). Spatially, increases in CPUE were most evident in the inshore part of the Subdivision in 2007 and 2008 (Fig. 170). In the offshore, the spatial distribution of fishing effort changed little in recent years, although there has been some effort along the north-west slope of St. Pierre Bank in 2007 and 2008 that was not present in 2005-2006. In the inshore, the distribution of fishing effort between Fortune and Placentia Bays has varied among years.

The fishery in offshore Subdiv. 3Ps has occurred much earlier in the past three years than during 2004-05. The timing of the 2008 fishery was very similar to that of 2006 and 2007 (Fig. 171a), starting in the first week of April and lasting 13 weeks. The fishery has started 3-5 weeks earlier in the past three years than it did in 2004-05, and has ended 2-5 weeks earlier. The level of recorded effort in logbooks has varied each year since 2004, but was at its lowest level, at about 250,000 trap hauls, in 2008.

Similar to the offshore, the inshore fishery in Subdiv. 3Ps has occurred much earlier in recent years than it did historically. In 2004, the inshore fishery commenced in early May (week 5 relative to April 1), and ended in week 24 (Fig. 171b). However, in the past three years, the fishery has started in early April, and ended progressively earlier. In 2008, the fishery was concluded by week 14. Effort expenditure, as recorded in logbooks, has been consistent, at about 150,000 trap hauls each year from 2005 to 2008, excepting an anomously low value for 2007.

Effect of ocean climate variation

Bottom temperature in Subdiv. 3Ps, at a seven year lag, has generally been inversely related to commercial CPUE since 1985 (Fig. 172). Bottom temperature declined sharply in 2008 while CPUE increased sharply. The spatial extent of the CIL in Subdiv. 3Ps, at a seven year lag, has generally reflected trends in CPUE (Fig. 173). Both indices increased sharply in 2008.

SUBDIVISION 3Ps OFFSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 174) have trended together since 1999. Both declined steadily from 1999-2003, and have since remained at a low level, despite increasing gradually each year since 2005. The VMS-based CPUE trend has agreed with the logbook and observer CPUE trends since 2004, increasing gradually over the past four years following a decrease from 2004 to 2005.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1999 (Fig. 175). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak in 2002. It then declined gradually in 2003 and 2004 before increasing sharply to its highest level of 75% in 2005. This is likely attributable to a high incidence of soft-shelled crab in the fishery in 2005 (Dawe et al. 2006). The spatial index declined sharply in 2006 and has since changed little, with about 50% of the available cells occupied by the fishery in 2006-08, while CPUE increased in the past three years, from its lowest level in 2005. The Subdiv. 3Ps offshore fishery primarily occurs around the bases of St. Pierre and Green Banks (Fig. 170) with smaller amounts of effort along the north-west slope of the St. Pierre Bank in some years.

Trends in commercial logbook CPUE throughout the season (Fig. 176) varied considerably across the past 5 years. Weekly CPUE (Fig. 176a) increased during the first half of the fishing season before declining in 2004, changed little throughout the season in 2007, and declined throughout most of the season in 2005, 2006, and 2008. This decline was most pronounced in 2008, suggesting depletion of the exploitable biomass. CPUE in 2008, in relation to week (Fig. 176a) as well as to cumulative catch (Fig. 176b) was initially much higher than in the four previous years. It remained higher than during the previous two years up to week 7 (Fig. 176a) and at comparable cumulative catches of about 2000 t (Fig. 176b), but by week 9 had declined to a level comparable with that of the previous three years (Fig. 176a). An increase in CPUE in the second last week of the 2008 season was associated with a small increase in catch. VMS-based CPUE trends in relation to week (Fig. 172a) and cumulative catch (Fig. 172b) were generally similar to logbook CPUE trends. However, the pattern of steady seasonal depletion noted in the logbook indices in 2008 was not evident in the VMS-based indices, such that, with few exceptions, VMS-based CPUE remained higher throughout the season in 2008 than in the previous four years (Fig. 177a), particularly at highest cumulative catch levels (Fig. 177b).

Trends in the logbook-based mean catch rate from the STRAP-based CPUE index (Fig. 178) were consistent with raw logbook CPUE, as both the 'all strata' and 'common strata' analyses indicated increasing catch rates since 2004. In 2008, the 'common strata' index rose more sharply than did the 'all strata' index. This may indicate that the recent increases in CPUE have not been as great in peripheral areas that are not fished each year, such as that along the NW slope of the St. Pierre Bank (Fig. 170).

Size distributions from at-sea sampling by observers (Fig. 179) showed a sharp ('knife-edge') decrease in catch rate at 95 mm CW from 2005 to 2007, suggesting high fishery-induced mortality on legal-sized crabs, including new-shelled immediate pre-recruits, in those years. However, this sharp knife-edge effect was not present in 2008, due to a decrease in catch rate of sub-legal sized crabs and an increase in catch rate of legal-sized crabs. This could be due to increased recruitment and/or decreased exploitation rate.. Catch rates of legal-sized old-shelled crabs decreased sharply for most sizes of crab in 2003 and remained low in 2004-05.

However,, there has been an increase in catch rates of old-shelled crabs from about 89-101 mm CW during 2005-07 and from about 103-110 mm CW in 2008, likely reflecting the progression of a modal group of adolescent pre-recruits observed in spring trawl survey size distributions in 2005 (Dawe et al. 2006). The high catch rates of undersized (<95 mm CW) crabs in most years, and the high proportion of those that were old shelled, suggests that crabs terminally molt to adulthood at small sizes in Subdiv. 3Ps relative to most other areas.

Observed catch rates of legal-sized old-shelled animals (Fig. 180a) declined sharply in 2003 and have since increased gradually. Observed catch rates of new-hard-shelled animals declined sharply two years earlier, in 2001, and continued to decline gradually to 2007 before increasing in 2008. Catch rates of old-shelled crabs have consistently been higher than those of new-hard-shelled crabs, and catch rates of soft-shelled crabs have been virtually absent each year after 1999, with the exception of 2005. Trends in the levels of intermediate and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the retained catch since 2000, with particularly tight agreement since 2003 (Fig. 180b).

Trends in the exploitable biomass are uncertain but the level remains low. The post-season trap survey exploitable biomass index increased slightly since 2004 (Fig. 181). Meanwhile the pre-season trawl survey exploitable biomass index has shown no trend and remains well below pre-2001 levels (Table 19, Fig. 181).

Production

Recruitment. The pre-season trawl survey indicates that recruitment has recently been increasing. This is reflected in the recent steady increase in the post-season trap survey exploitable biomass index (Fig. 181) while landings increased (Fig. 168). Also, the post-season trap survey index of legal-sized new-shelled crabs increased in 2006 and has since changed little (Fig. 182).

Catch rates of legal-sized old-shelled crabs in the post-season trap survey increased in 2005, changed little to 2007, and increased further in 2008 (Fig. 182). The biomass index of new-shelled legal-sized crabs in the pre-season trawl survey decreased greatly from 1996-97 and has since remained low (Fig. 183a). This decline in new-shelled legal-sized crabs was followed by a sharp increase in the biomass indices of intermediate and old-shelled crabs in 1998 and 1999. The biomass indices of legal-sized intermediate and old-shelled crabs subsequently declined greatly during 2000-01, and have since been variable, remaining at low levels. The percentage of the catch in the trawl survey that was soft and new-hard-shelled increased in 2005 (Fig. 183b), while there have been increases in the percentages of intermediate-shelled crabs in 2007-08, consistent with the recent increases in recruitment noted from the post-season trap survey.

Size distributions from the post-season trap survey showed a substantial increase in catch rates of sub-legal-sized new-shelled crabs in 2006 and a gradual increase in catch rates of most sizes of new and old-shelled legal-sized crabs since then (Fig. 184). The high catch rates of undersized (<95 mm CW) crabs in most years, and the high proportion of those that were old shelled (Fig. 184), supports our earlier suggestion that crabs terminally molt to adulthood at smaller sizes in Subdiv. 3Ps relative to other areas.

Size distributions from the spring trawl survey reflect the presence of a modal group of adolescents first observed in 2005 at a modal size of about 65 mm CW (Fig. 185). These adolescents achieved a modal size of about 86 mm CW in 2008 (Fig. 185), and so are expected to achieve legal size and subsequently recruit to the exploitable biomass over the next several years. It is apparent (e.g,. in 1999, Fig. 185) that a very low proportion of crabs enter legal size as adolescents in Subdiv. 3Ps relative to some other areas (such as Div. 3NO, Fig. 160), supporting our assertion that male crabs terminally molt to adulthood at relatively small size in this area. Furthermore, a high proportion of the 86 mm CW modal group of adolescents (Fig. 185) were classed as intermediate-shelled in 2008 (Fig. 186). This could be indicative of a high incidence of skip-molting by adolescent crabs in this area.

This represents the only area where the observer catch rate of under-sized discards (from at-sea sampling) commonly exceeds that of total discards (from set and catch data) (Fig. 187). This indicates that either the under-sized discards are over-estimated or the total discards are under-estimated. However, that this is unique to Subdiv. 3Ps also suggests that under-sized discards represents a higher proportion of the total discards in Subdiv. 3Ps than in other divisions. Trends in the observed catch rates of under-sized crabs generally tracked those of total discards up to 2005, suggesting that the ratio of under-sized to soft-shelled discards has changed little during that time. The catch rate of total discards exceeded that of under-sized discards most greatly in 2005, consistent with the relatively high incidence of soft-shelled crab in the catches during that year (Fig. 180). The catch rate of under-sized crabs increased marginally from 2005 to 2007 before decreasing in 2008 (Fig. 187). Meanwhile, catch rates of total discards declined considerably from 2005 to 2007 and changed little in 2008. This suggests there has been a decrease in the proportion of soft-shelled crabs in the discards from 2005 to 2007 and an increase in 2008, consistent with trends in the size composition of the catch described earlier (Fig. 179).

Recruitment is expected to increase further over the next two to three years. The pre-season trawl survey pre-recruit index increased steadily from 2003 to 2008 to its highest level since 1996 (Table 20, Fig. 188). This increase is related to a modal group of adolescents first observed in the spring trawl survey size distributions in 2005, which achieved a modal size of about 86 mm CW in 2008.

Reproduction. The number of females captured increased sharply from 2001 to 2002, and has since declined to a low level in 2007-08.There is high annual variability in the percentage of females carrying full clutches of viable eggs (Fig. 189). Nearly 100% of females carried full clutches in 2008.

Mortality

Exploitation. Exploitation rate indices based on trap and trawl surveys have shown no consistent trend over the past 4 years. The trawl survey pre-recruit fishing mortality index has declined sharply since 2003 to a very low level (Fig. 190). Maintaining the current level of fishery removals would not likely result in a substantial change in fishery-induced mortality.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 190) almost doubled to about 45% in 2005 and declined to about 22% in 2008, implying a reduction in wastage of pre-recruits in recent years. The percent discarded in Subdiv. 3Ps is generally higher than in other areas as it includes a larger component of under-sized crabs, an unknown portion of which is comprised of small adults that will never recruit to the fishery. With the exception of 2005, the observed weekly prevalence of soft-shelled crab has been less than 2% in most weeks since 2004 (Fig. 191).

The fishery started and ended earlier in 2006-08 than in previous years (Fig. 192).

In 2008, there was a bimodal distribution in both fishing effort and observer coverage, with an initial peak in weeks 3-4, and a secondary peak in week 9. The distribution of observed sets has generally reflected that of total fishing effort, since 2005, inferring observed trends in soft-shell crab prevalence have been representative of the entire fishery.

Natural Mortality (BCD). Small-meshed trap data from the collaborative post-season trap survey indicates that BCD has been detected, at low prevalence levels in offshore Subdiv. 3Ps in 2005-06, but not in 2007-08 (unpublished data).

SUBDIVISION 3Ps INSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 193) both increased in 2008. Commercial logbook CPUE declined from 2001 to a record low level in 2004-05, but has since about doubled. Similarly, observer CPUE declined sharply from 2001 to 2003, and has since about doubled. An anomalous peak in 2004 in the observer index, inconsistent with the trend in logbook CPUE for that year, is attributable to temporal bias in observer deployments in 2004.

The Subdiv. 3Ps inshore fishery primarily occurs in Placentia Bay to the east, with smaller amounts of effort in Fortune Bay to the west (Fig. 170). The commercial fishery in Fortune Bay has been closed since 2005, with a small-scale indexing fishery occurring each year since. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 194). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak of 23% in 2000. Conversely, CPUE declined by 44% during this period. A sharp increase in CPUE in 2001 contrasted a sharper decrease in spatial coverage of the fishery. CPUE then decreased abruptly in 2002 while the spatial coverage of the fishery sharply increased back to the 2000 level. From 2004 to 2007, the slight increase in CPUE was associated with a gradual decrease in the percentage of available cells occupied by the fishery. The inverse relationship did not hold in 2008, as the sharp increase in CPUE was associated with a slight increase in the spatial index.

Trends in commercial CPUE throughout the season (Fig. 195) indicated that CPUE was considerably higher throughout the season in 2008 than in any of the previous 4 years. A pattern of late-season depletion was evident during 2004-05, following a peak that occurred in week 8 (2005) or 9 (2004) (Fig. 195a). This peak corresponded to a cumulative catch of about 500 t during 2004, and a cumulative catch of less than 200 t in 2005 (Fig. 195b). Such a peak in CPUE and subsequent depletion was not evident in subsequent years (2006-08, Fig. 195a). CPUE throughout the season approximately doubled between 2006 (about 4 kg/trap) and 2008 (about 8 kg/trap), even at late-season cumulative removal levels that were about twice as high in 2008 as in 2006 (Fig. 195b).

Trends in the logbook mean catch rate from the STRAP-based CPUE index (Fig. 196) were consistent with raw logbook CPUE trends, as both the 'all strata' and 'common strata' analyses indicated increasing catch rates since 2005. The tight agreement in between the 'common strata' and 'all strata' indices likely reflects increased CPUE throughout inshore Subdiv. 3Ps.

Size distributions from at-sea sampling by observers (Fig. 197) were very similar to those from the offshore fishery (Fig. 179). They showed an increasingly sharp ('knife-edge') decrease in catch rate at 95 mm CW from 2001 to 2006, reflecting effects of high fishery-induced mortality on legal-sized crabs including new-shelled immediate pre-recruits. This knife-edge effect was less prominent in 2007 and non-existent in 2008.

A decrease in the catch rate of under-sized new-shelled crabs and an increase in the catch rate of legal-sized crabs in 2008 (Fig. 197), as also observed offshore (Fig. 179), was likely due to increase in recruitment and possibly decrease in exploitation rate.

Peaks in observed catch rates of old-shelled legal-sized crabs have not been preceded by peaks in catch rates of new-shelled legal-sized crabs, as in some other divisions, but rather tended to trend together (Fig. 198a). This may reflect subjectivity in classification of shell categories by observers. Catch rates of soft-shelled crab constituted 0-1% of the catch since 2000, excepting a sharp increase to 3% in 2005. Trends in catch rates of new-hard and old-shelled legal-sized crab, when combined, have reflected the retained catch throughout most of the time series (Fig. 198b). This relationship has been especially tight since 2006, in showing steadily increasing catch rates in recent years. Disagreement between these catch rates especially during 2004 and 2005, could be due to low levels of observer sampling, spatial or temporal variation in observer sampling, or classification of some soft-shelled crabs as new-hard-shelled.

The exploitable biomass has recently increased. The post-season trap survey exploitable biomass index increased substantially from 2006 to 2008 (Fig. 199).

Production

Recruitment. Recruitment has recently been increasing. This is reflected in the recent steady increase in the post-season trap survey exploitable biomass index (Fig. 199) while landings increased (Fig. 168). Also, the post-season trap survey index of legal-sized new-shelled crabs has increased substantially from 2004 to 2008 (Fig. 200).

Size distributions from the post-season collaborative trap survey showed a substantial increase in catch rates across all sizes and shell categories in 2007, particularly in sub-legal-sized and old-shelled crabs (Fig. 201). This was followed by a decrease in catch rates of under-sized (particularly new-shelled) crabs and an increases in catch rate of legal-sized crabs in 2008, indicative of a recruitment pulse entering the fishery.

Trends in the observed catch rates of under-sized crabs differed from the catch rates of total discards prior to 2006 (Fig. 202), suggesting that soft-shelled crab represented a variable component of total discards. The catch rate of total discards exceeded that of undersized crabs most greatly in 2005, as was true to a lesser extent offshore (Fig. 187). This implies a high incidence of soft-shelled crab, as was observed offshore in 2005 (Figs. 191, 198). Catch rates of total discards and under-sized crabs have agreed during the past three years, indicating that discards have been comprised almost exclusively of under-sized crabs. Both were at a high level in 2006-07, before decreasing sharply in 2008, consistent with an increase in recruitment to the fishery.

The post-season trap survey indicates that recruitment prospects remain promising in the short-term. The post-season trap survey catch rate of undersized crabs (Fig. 203) increased substantially from 2004 to 2007 and decreased, while remaining relatively high in 2008.

Reproduction. No data.

Mortality

Exploitation. The post-season trap survey-based exploitation rate index fluctuated without trend during 2005-08 (Fig. 204). Data are insufficient to estimate pre-recruit fishing mortality rates. Fishery removals could likely be increased in 2009 without increasing the exploitation rate.

Indirect fishing mortality. The percentage of the total catch discarded in the fishery (Fig. 205) was at its highest, about 60%, in 2005 and 2006. It has since decreased substantially to about 30% in 2008, implying reduced wastage of pre-recruits in recent years.

The observed percentage of soft-shelled crab in the catch (Fig. 206) remained low in all weeks from 2006 to 2008. Generally, soft-shelled crab catch rates have been very low in Subdiv. 3Ps inshore. However soft-shelled crab prevalence exceeded 20% during some weeks of the 2005 season (Fig. 206), as well as in 2002-03 (Dawe et al. 2009).

The fishery has occurred earlier in the past three years than in previous years (Fig. 207). The 2005 fishery did not start until late May (week 7), and ended in mid July (week 15). In contrast, during the past three years, the fishery has begun in early April (week 1) and ended by late May (weeks 10-12). In 2008, 68% of the fishing effort was expended by the first week of June (week 5). The distribution of observer coverage has been disproportionate to the distribution of fishing effort in some years, most notably in 2004 when there was observer coverage only during the first half of the fishery. Such temporal bias in observer sampling in some years has biased some of the analyses, for example resulting in the anomalously high observer CPUE in 2004 (Figs. 193 and 198).

Natural Mortality (BCD). Small-meshed trap data from the collaborative post-season trap survey indicates that BCD has occasionally been detected, at low prevalence levels, in inshore Subdiv. 3Ps.

DIVISION 4R AND SUBDIVISION 3Pn

The Fishery

Landings (Table 8, Fig. 208) have generally been comparable between inshore and offshore areas. The TACs have not been taken since 2002. Offshore landings and effort peaked in 2002 before declining to historical lows in 2006 (Fig. 208). Landings and effort have been variable in recent years, but remained at low levels. Inshore Landings declined by 74% from 950 t in 2003 to a record low of 250 t in 2008 (Fig. 208). Inshore effort decreased sharply in 2005 and changed little since (Fig. 208).

Commercial CPUE (Table 8, Fig. 209) has been higher in inshore than in offshore areas but low relative to other divisions. Offshore CPUE is strongly affected by spatial changes in distribution of fishing effort. Inshore CPUE has steadily declined since 2002 to its lowest level in 2008.

The spatial distribution of fishing effort has changed substantially since 2002 (Fig. 210). Effort has become highly aggregated, both offshore and inshore, within a few localized areas.

The fishery in offshore Div. 4R3Pn has occurred earlier in the past three years than during 2004-05. The timing of the 2008 fishery was very similar to that of 2006 and 2007 (Fig. 211a), starting in early April and lasting 13-14 weeks. The level of recorded effort in logbooks has varied each year since 2004. It was at a low level, of about 30,000 trap hauls in 2008 (Fig. 211a).

Similar to the offshore, the fishery in inshore Div. 4R3Pn has occurred earlier in the past three years than in previous years. The timing of the fishery has changed little since 2005 (Fig. 211b), with most effort expended by week 14. The level of recorded effort in logbooks has varied each year since 2004, but has been at it's lowest level, of about 45,000 trap hauls for each of the past two years.

DIVISION 4R AND SUBDIVISION 3Pn OFFSHORE

There are insufficient data to assess resource status.

Biomass

Trends in exploitable biomass are unknown. It is not possible to infer trends in exploitable biomass from CPUE data (Fig. 212) because of recent changes in the spatial distribution (steady contraction) of fishing effort (Fig. 210). Logbook CPUE has remained below 4 kg/trap since 2003, while VMS-based CPUE has gradually declined since 2004.

In contrast to other areas, CPUE and the spatial extent of the fishery have generally been directly related over most of the time series (Fig. 213). However, an inverse relationship between the two indices, as evident in other areas, has persisted since 2004. Despite this, both CPUE and the spatial extent of the fishery have been at their lowest levels in the past four years.

Trends in commercial CPUE throughout the season, according to both weekly (Fig. 214a) and cumulative catch (Fig. 214b), substantially decreased in 2006 and have changed little since. Trends in VMS-based CPUE throughout the season, according to both weekly (Fig. 215a) and cumulative catch (Fig. 215b), were similar to those from logbook CPUE, showing catch rates to be lower throughout the season in the past three years than in 2004 and 2005. CPUE throughout the season consistently showed a pattern of seasonal depletion, with catch rates steadily declining after the early portions of the season (Figs. 214-215).

The broken time series from the post-season collaborative trap survey (2003 and 2007-08) is inadequate to infer biomass trends. The catch rate of legal-sized crabs changed little from 2007 to 2008 (Fig. 216). The catch rate of legal-sized old-shelled crabs increased in 2008 (Fig. 216). This is associated with a large decrease in catch rates of sub-legal-sized crabs from 2007 to 2008 (Figs. 216-217). However, there is an inconsistency here in that the catch rate of legal-sized new-shelled crabs would be expected to increase prior to that of old-shelled crabs as a recruitment pulse enters into the fishery. This inconsistency contributes further to the inadequacy of this limited data series.

Production

Recruitment. There are no data available that could be used to infer recruitment. Therefore, short-term recruitment prospects are unknown.

Reproduction. No data.

Mortality

Exploitation. Trends in fishing mortality on either the exploitable or pre-recruit population are unknown.

Indirect fishing mortality. The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Natural Mortality (BCD). No data.

DIVISION 4R AND SUBDIVISION 3Pn INSHORE

Biomass

Both CPUE and the spatial extent of the fishery increased sharply in 2002 (Fig. 218), but both indices have since steadily declined.

Annual trends in CPUE are influenced by the spatial contraction of the fishery. However, trends in commercial logbook CPUE throughout the season (Fig. 219) have declined each year since 2004, and were at their lowest levels in 2008.

Post-season trap survey catch rates show that the exploitable biomass declined from 2004–06 and changed little since (Fig. 220).

Production

Recruitment. Recruitment is expected to change little over the next 2-3 years. The post-season trap survey catch rate of undersized crabs (Fig. 221) has changed little after it decreased between 2004 and 2006.

Reproduction. No data.

Mortality

Exploitation. Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2009.

Indirect fishing mortality. The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Natural Mortality (BCD). No data.

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Table 1. TAC (t) and Landings (t) by year for Division 2J3KLNOPs4R.

Year	TAC	Landings
1995	27,875	32,334
1996	34,864	37,967
1997	42,015	45,726
1998	46,525	52,677
1999	61,761	69,131
2000	51,169	55,434
2001	52,252	56,727
2002	56,981	59,418
2003	56,330	58,362
2004	53,590	55,675
2005	49,978	43,958
2006	46,233	47,238
2007	47,663	50,207
2008	54,338	52,775

Table 2. TAC (t), Landings (t), Effort (trap hauls), and CPUE (kg/trap) by year for Division 2H.

Year	TAC	Landings	Effort	CPUE
2004		10	3,030	3.3
2005		67	10,469	6.4
2006		152	11,014	13.8
2007		193	16,083	12
2008	100	141	17,195	8.2

Table 3. TAC (t), Landings (t), Effort (trap hauls), and CPUE (kg/trap) by year for Division 2J.

Year	TAC	Landings	Effort	CPUE
1995	3,050	3,189	393,704	8.1
1996	2,800	3,102	326,526	9.5
1997	2,800	3,183	286,757	11.1
1998	3,500	4,098	284,583	14.4
1999	4,655	5,416	401,185	13.5
2000	3,411	3,682	304,298	12.1
2001	3,340	3,754	426,591	8.8
2002	3,381	3,520	577,049	6.1
2003	2,265	2,510	583,721	4.3
2004	1,780	1,915	531,944	3.6
2005	1,425	1,509	284,717	5.3
2006	1,425	1,987	242,317	8.2
2007	1,570	2,330	258,889	9
2008	2,366	2,408	231,538	10.4

Table 4. TAC (t), Landings (t), Effort (trap hauls), and CPUE (kg/trap) by year for Division 3K inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1995	1,950	1,950	237,805	8.2	9,500	10,376	741,143	14.0
1996	3,450	3,267	510,469	6.4	9,500	10,943	835,344	13.1
1997	3,450	3,122	538,276	5.8	10,850	11,674	871,194	13.4
1998	3,040	2,781	487,895	5.7	12,700	14,103	946,510	14.9
1999	3,242	3,460	865,000	4.0	14,950	17,898	1,345,714	13.3
2000	2,275	2,328	485,000	4.8	11,218	13,056	1,186,909	11.0
2001	2,475	2,757	306,333	9.0	11,218	12,519	1,251,900	10.0
2002	3,195	3,481	429,753	8.1	12,183	12,870	1,191,667	10.8
2003	3,425	3,585	535,075	6.7	12,183	12,922	1,242,500	10.4
2004	3,410	3,527	665,472	5.3	12,183	12,943	1,703,026	7.6
2005	3,115	2,707	575,957	4.7	9,745	5,972	853,143	7.0
2006	2,635	2,728	426,250	6.4	7,795	7,984	694,261	11.5
2007	2,820	3,056	315,052	9.7	8,930	9,215	626,871	14.7
2008	3,455	3,456	300,522	11.5	11,620	11,612	699,518	16.6

Table 5. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Division 3L inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1995	6,475	6,795	471,875	14.4	5,175	7,212	389,838	18.5
1996	7,675	7,922	665,714	11.9	7,100	8,494	534,214	15.9
1997	5,850	6,398	627,255	10.2	13,075	14,293	893,313	16.0
1998	7,225	6,882	583,220	11.8	12,750	14,465	836,127	17.3
1999	5,350	5,453	482,566	11.3	21,025	21,651	1,223,220	17.7
2000	4,633	4,731	407,845	11.6	18,077	18,700	973,958	19.2
2001	5,615	5,543	518,037	10.7	18,040	18,794	1,005,027	18.7
2002	6,540	6,524	582,500	11.2	18,903	20,091	1,097,869	18.3
2003	6,774	6,814	841,235	8.1	19,598	20,782	1,251,928	16.6
2004	6,255	6,421	823,205	7.8	20,028	20,846	1,457,762	14.3
2005	6,045	6,114	745,610	8.2	20,028	19,949	1,435,180	13.9
2006	6,095	6,229	648,854	9.6	20,028	20,313	1,515,896	13.4
2007	6,105	6,485	600,463	10.8	20,028	20,136	1,721,026	11.7
2008	7,033	6,823	573,361	11.9	19,608	18,989	1,726,273	11.0

Table 6. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Division 3NO.

Year	TAC	Landings	Effort	CPUE
1998	500	646	36,089	17.9
1999	3,250	5,678	294,197	19.3
2000	2,425	3,383	175,285	19.3
2001	2,425	3,836	197,732	19.4
2002	3,430	3,437	170,149	20.2
2003	4,105	4,046	211,832	19.1
2004	3,675	3,830	250,327	15.3
2005	3,675	3,608	255,887	14.1
2006	3,675	4,201	272,792	15.4
2007	3,675	4,269	344,274	12.4
2008	4,540	4,386	402,385	10.9

Table 7. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Subdivision 3Ps inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1995	1,200	1,035	161,719	6.4	525	894	45,846	19.5
1996	1,350	1,309	73,955	17.7	1,700	1,665	99,701	16.7
1997	2,400	2,305	187,398	12.3	2,200	2,370	117,910	20.1
1998	2,500	3,367	333,366	10.1	3,700	3,257	134,033	24.3
1999	3,701	3,598	342,667	10.5	4,298	4,307	177,975	24.2
2000	3,300	3,501	350,100	10.0	4,400	4,386	212,913	20.6
2001	3,200	3,436	279,350	12.3	4,400	4,403	271,790	16.2
2002	3,200	3,280	410,000	8.0	4,400	4,357	360,083	12.1
2003	2,469	2,206	387,018	5.7	3,616	3,907	470,723	8.3
2004	1,590	1,220	348,571	3.5	2,805	3,500	432,099	8.1
2005	1,300	658	193,529	3.4	2,800	2,515	405,645	6.2
2006	975	762	195,385	3.9	2,070	2,343	312,400	7.5
2007	975	1,100	207,547	5.3	2,270	2,862	381,600	7.5
2008	1,128	1,346	162,169	8.3	3,230	3,176	286,126	11.1

Table 8. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Division 4R3Pn inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1998	1,310	1,067	197,593	5.4				3.7
1999	690	988	161,967	6.1	645	629	149,762	4.2
2000	785	954	190,800	5.0	645	674	134,800	5.0
2001	909	1,026	190,000	5.4	635	649	147,500	4.4
2002	904	878	100,920	8.7	845	977	195,400	5.0
2003	1,050	954	117,778	8.1	845	608	168,889	3.6
2004	1,016	877	139,206	6.3	838	584	182,500	3.2
2005	1,000	511	81,111	6.3	845	348	108,750	3.2
2006	860	460	85,185	5.4	675	79	22,571	3.5
2007	750	368	85,581	4.3	540	194	77,600	2.5
2008	718	250	65,789	3.8	540	131	37,429	3.5

Table 9. Fall trawl survey exploitable Biomass index by year for Division 2H, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-) Upper	Confidence Intervals (+/-) Lower	Mean kg/set
1996	67	321	-187	0.05
1997	67	321	-187	0.05
1998	25	241	-190	0.02
1999	0	0	0	0.00
2000				
2001				
2002				
2003				
2004	142	322	-37	0.08
2005				
2006	304	951	-344	0.18
2007				
2008	103	471	-265	0.07

Table 10. Fall trawls survey pre-recruit Biomass index by year for Division 2H, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-) Upper	Confidence Intervals (+/-) Lower	Mean kg/set
1996	1,123	4,617	-2,371	0.39
1997	1,123	4,617	-2,371	0.39
1998	13	172	-147	0.01
1999	0	0	0	0.00
2000				
2001				
2002				
2003				
2004	443	950	-65	0.26
2005				
2006	142	300	-16	0.08
2007				
2008	67	321	-187	0.05

Table 11. Fall trawl survey exploitable Biomass index by year for Division 2J, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	3,367	4,742	1,991	1.13
1996	5,546	7,655	3,437	1.87
1997	10,196	16,238	4,155	3.43
1998	12,376	18,154	6,598	4.17
1999	6,117	8,159	4,075	2.06
2000	3,506	4,437	2,574	1.18
2001	3,161	3,775	2,346	1.06
2002	798	1,283	314	0.27
2003	945	1,600	291	0.32
2004	1,389	2,070	709	0.47
2005	2,005	10,441	-6,431	0.68
2006	2,317	3,066	1,569	0.78
2007	2,547	4,176	918	0.86
2008	1,731	2,407	1,055	0.60

Table 12. Fall trawl survey pre-recruit Biomass index by year for Division 2J, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	1,937	2,832	1,042	0.65
1996	2,339	3,467	1,211	0.79
1997	2,783	4,182	1,384	0.94
1998	3,384	4,523	2,244	1.14
1999	1,082	1,999	165	0.36
2000	1,211	1,759	663	0.41
2001	1,254	3,095	-587	0.42
2002	547	2,992	-1,897	0.18
2003	835	1,224	426	0.28
2004	4,716	34,239	-24,806	1.59
2005	1,542	3,591	-507	0.52
2006	1,715	3,575	-144	0.58
2007	1,153	280	-493	0.39
2008	1,123	4,617	-2,371	0.39

Table 13. Fall trawl survey exploitable Biomass index by year for Division 3K, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	10,073	12,679	7,467	2.06
1996	19,373	23,470	15,276	3.97
1997	18,486	22,667	14,306	3.79
1998	18,457	22,938	13,976	3.84
1999	8,408	10,919	5,898	1.72
2000	9,791	12,192	7,390	2.01
2001	11,143	15,688	6,599	2.28
2002	8,615	11,232	5,998	1.76
2003	3,567	4,555	2,579	0.73
2004	5,479	6,938	4,020	1.12
2005	6,733	8,584	4,883	1.38
2006	10,310	12,601	8,020	2.11
2007	15,801	21,175	10,427	3.24
2008	14,317	18,413	10,221	3.13

Table 14. Fall trawl survey pre-recruit Biomass index by year for Division 3K, with 95% confidence intervals and mean catch rate.

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	6,413	8,932	3,893	1.31
1996	10,010	13,648	6,372	2.05
1997	12,880	17,255	8,505	2.64
1998	9,790	13,861	5,720	2.03
1999	3,400	4,811	1,990	0.70
2000	8,925	12,365	5,485	1.83
2001	6,287	8,517	4,058	1.29
2002	4,796	6,852	2,740	0.98
2003	2,340	4,193	488	0.48
2004	5,416	9,200	1,631	1.11
2005	5,678	7,835	3,521	1.16
2006	9,582	14,671	4,494	1.96
2007	4,972	6,826	3,119	1.02
2008	7,174	10,578	3,769	1.57

Table 15. Fall trawl survey exploitable Biomass index by year for Division 3L, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2004).

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	19,527	25,572	13,482	3.39
1996	31,093	38,009	24,176	5.36
1997	18,577	24,107	13,046	3.20
1998	22,054	28,023	16,085	3.80
1999	12,197	15,515	8,879	2.10
2000	9,101	13,256	4,947	1.57
2001	11,577	15,429	7,725	2.00
2002	11,044	16,243	5,845	1.90
2003	9,456	13,202	5,709	1.63
2004				
2005	9,403	18,172	634	1.63
2006	3,800	5,101	2,500	0.66
2007	6,164	8,210	4,118	1.06
2008	9,665	13,572	5,758	1.70

Table 16. Fall trawl survey pre-recruit Biomass index by year for Division 3L, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2004).

Year	Biomass (t)	Confidence Intervals (+/-)		Mean
		Upper	Lower	kg/set
1995	9,061	12,743	5,379	1.57
1996	25,343	33,387	17,298	4.37
1997	8,011	10,736	5,286	1.38
1998	8,507	11,163	5,851	1.47
1999	4,454	6,708	2,200	0.77
2000	4,623	7,222	2,024	0.80
2001	2,916	4,587	1,245	0.50
2002	2,205	3,004	1,407	0.38
2003	4,278	6,842	1,713	0.74
2004				
2005	2,746	4,910	582	0.48
2006	1,488	2,077	899	0.26
2007	5,860	8,265	3,456	1.01
2008	13,080	19,629	6,532	2.30

Table 17. Fall trawl survey exploitable Biomass index by year for Division 3NO, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

		Confidence Intervals (+/-)		Mean
Year	Biomass (t)	Upper	Lower	kg/set
1995	3,009	4,561	1,456	0.70
1996	7,775	12,351	3,199	1.81
1997	5,975	8,791	3,158	1.39
1998	12,598	24,382	814	2.93
1999	9,893	15,864	3,922	2.25
2000	5,560	8,977	2,144	1.29
2001	10,191	16,293	4,089	2.37
2002	4,980	7,528	2,432	1.16
2003	4,609	7,156	2,062	1.07
2004	5,206	10,965	-552	1.21
2005	997	1,751	243	0.23
2006				
2007	2,264	6,690	-216	0.53
2008	1,666	2,406	926	0.39

Table 18. Fall trawl survey pre-recruit Biomass index by year for Division 3NO, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

		Confidence Intervals (+/-)		Mean
Year	Biomass (t)	Upper	Lower	kg/set
1995	2,903	18,488	-12,683	0.67
1996	8,346	22,603	-5,910	1.94
1997	7,067	48,196	-34,062	1.64
1998	11,506	69,380	-46,368	2.67
1999	8,806	22,905	-5,292	2.00
2000	4,187	7,839	536	0.97
2001	5,066	7,642	2,490	1.18
2002	2,114	4,902	-673	0.49
2003	2,134	3,755	513	0.50
2004	1,369	12,217	-9,479	0.32
2005	425	987	-138	0.10
2006				
2007	1,453	3,599	-693	0.34
2008	1,722	2,988	457	0.40

Table 19. Spring trawl survey exploitable Biomass index by year for Subdiv. 3Ps, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1996	4,350	7,633	1,066	1.69
1997	1,111	1,684	539	0.43
1998	1,561	2,382	739	0.61
1999	2,438	4,090	786	0.95
2000	878	1,356	401	0.33
2001	491	779	204	0.19
2002	367	561	174	0.14
2003	419	1,156	-318	0.16
2004	194	293	94	0.08
2005	490	884	96	0.19
2006				
2007	207	364	50	0.08
2008	354	527	182	0.35

Table 20. Spring trawl survey pre-recruit Biomass index by year for Subdiv. 3Ps, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

Year	Biomass (t)	Confidence Intervals (+/-)		Mean kg/set
		Upper	Lower	
1996	1,742	3,563	-793	0.68
1997	278	531	26	0.11
1998	650	1,175	124	0.25
1999	300	459	142	0.12
2000	202	392	13	0.08
2001	290	610	-30	0.11
2002	281	452	110	0.11
2003	79	175	-17	0.03
2004	186	312	59	0.07
2005	427	619	235	0.17
2006				
2007	709	1,657	-239	0.28
2008	1,020	2.896	-856	0.40

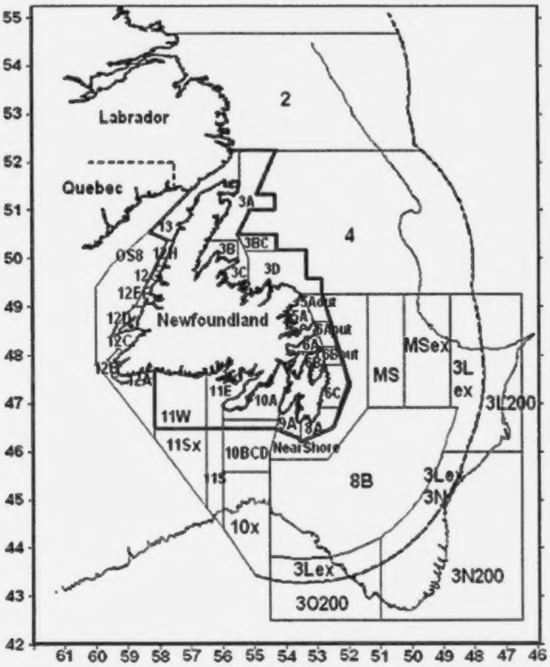

55
54
53
52
51
50
49
48
47
46
45
44
43
42
61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46
Labrador
Quebec
Newfoundland
2
4
3A
3B
3BC
3C
3D
13
12H
OS8
12G
12E
12D
12C
12B
12A
11E
11W
11Sx
11S
10A
10BCD
10x
9A
8A
NearShore
5A
5Aout
6A
6B
6Bout
6C
MS
MSex
3L ex
3L200
8B
3Lex
3N
3Lex
3N200
3O200

Figure 1. Newfoundland and Labrador Snow Crab Management areas. (Red line shows division of inshore vs. offshore CMAs)

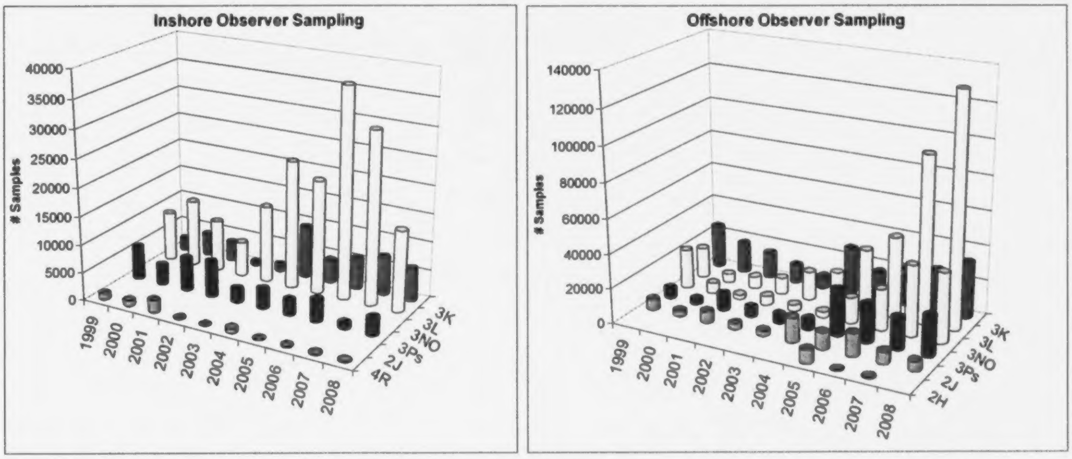
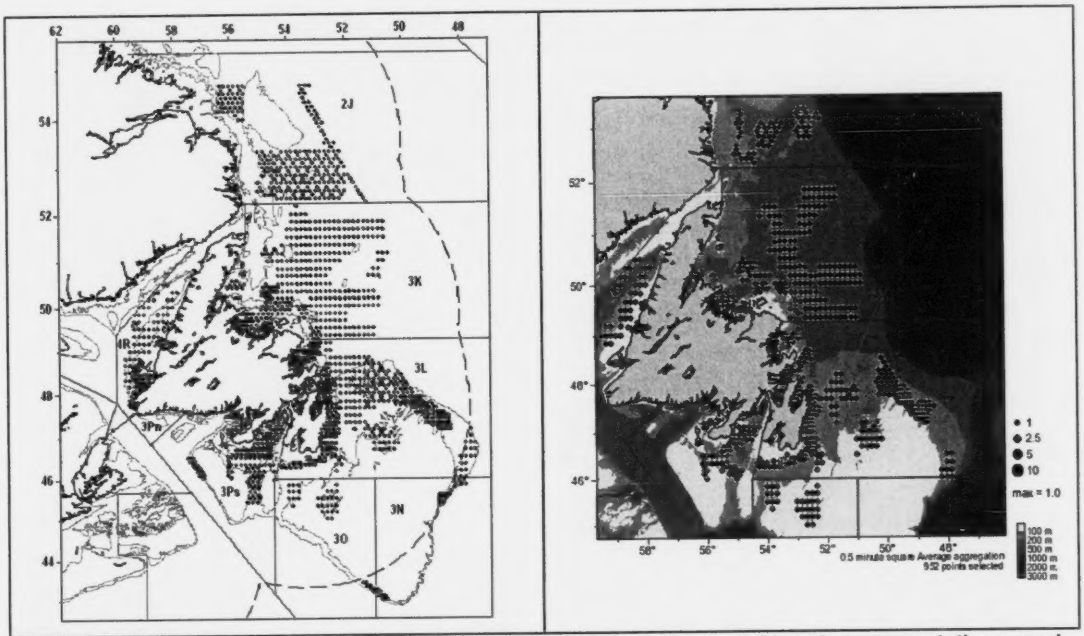


Figure 2. Observer sampling for inshore (left) and offshore (right) areas within each division by year.



62
60
58
56
54
52
50
48
54
52
50
48
46
44
2J
3K
3L
4R
3Pn
3Ps
3N
3O
52°
50°
48°
46°
58°
56°
54°
52°
50°
48°
0.5 minute square Average aggregation
952 points selected
1
2.5
5
10
max = 1.0
100 m
200 m
500 m
1000 m
2000 m
3000 m

Figure 3. Industry – DFO collaborative post-season trap survey design (left) and common stations used for data analyses (right).

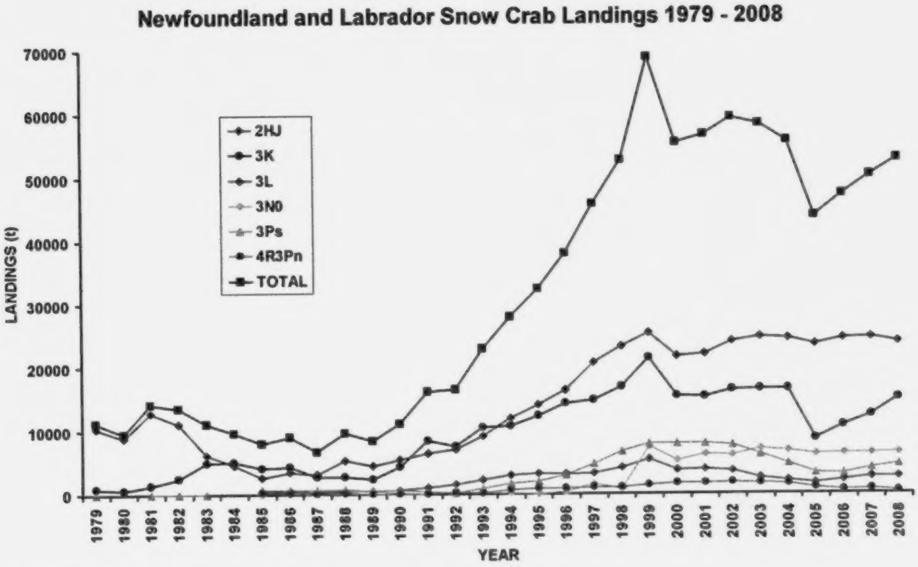
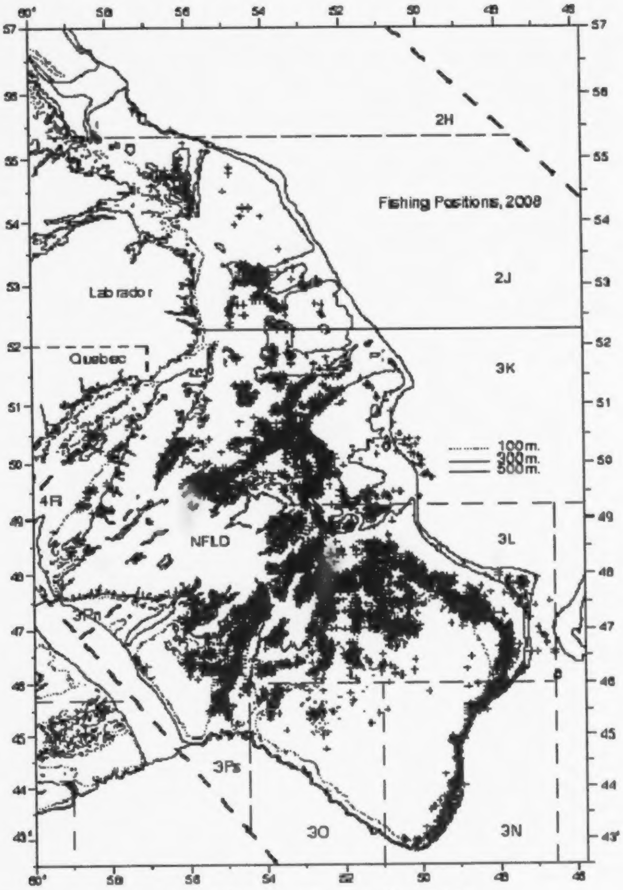


Figure 4. Trends in landings by NAFO Division and in total.



60°
58
56
54
52
50
48
46
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43°
2H
Fishing Positions, 2008
2J
Labrador
Quebec
3K
100m.
300m.
500m.
4R
NFLD
3L
3Pn
3Ps
3O
3N

Figure 5. Spatial distribution of commercial fishing effort during 2008.

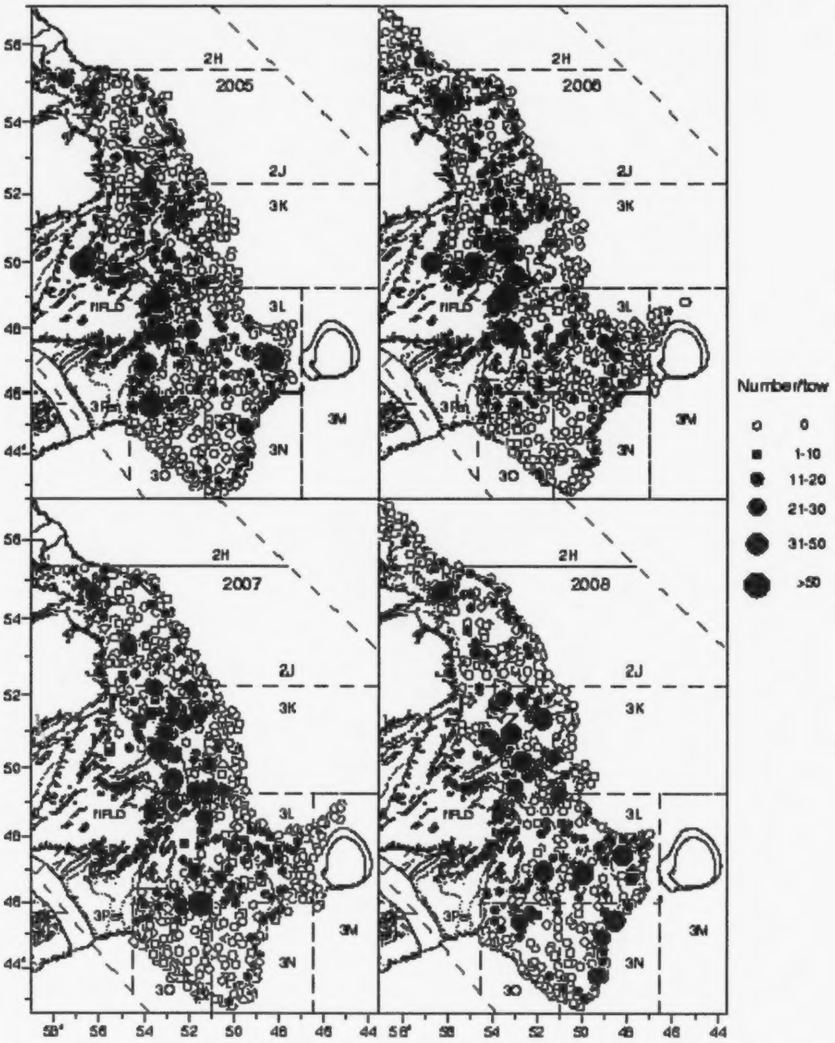

2H
2005
2006
2007
2008
2J
3K
3L
3M
3N
3O
3Ps
NFLD
Number/tow
0
1-10
11-20
21-30
31-50
>50
56
54
52
50
48
46
44
58
56
54
52
50
48
46
44

Figure 6. Distribution of exploitable males (> 94 mm CW adults) from fall Division 2J3KLNO bottom trawl surveys from 2005 to 2008.

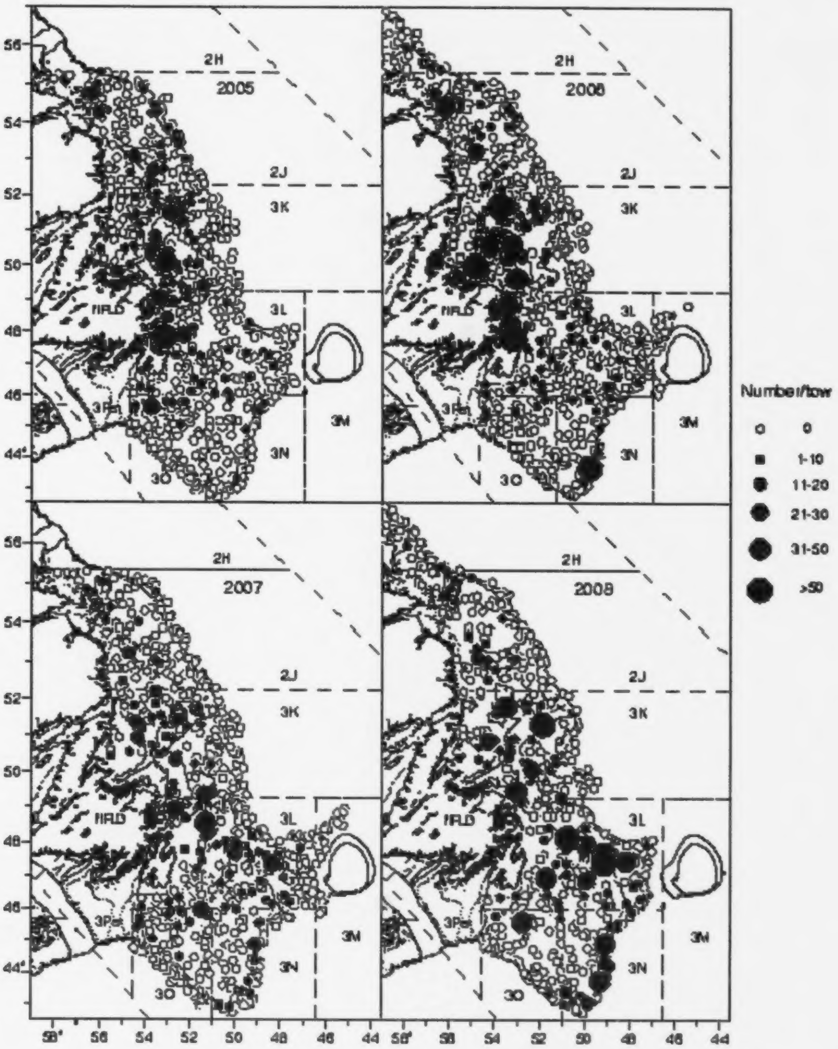

2H
2005
2006
2007
2008
2J
3K
3L
3M
3N
3O
3Ps
NFLD
Number/tow
0
1-10
11-20
21-30
31-50
>50
56
54
52
50
48
46
44
58
56
54
52
50
48
46
44

Figure 7. Distribution of pre-recruit males (>75 mm CW adolescents) from fall Division 2J3KLNO bottom trawl surveys from 2005 to 2008.

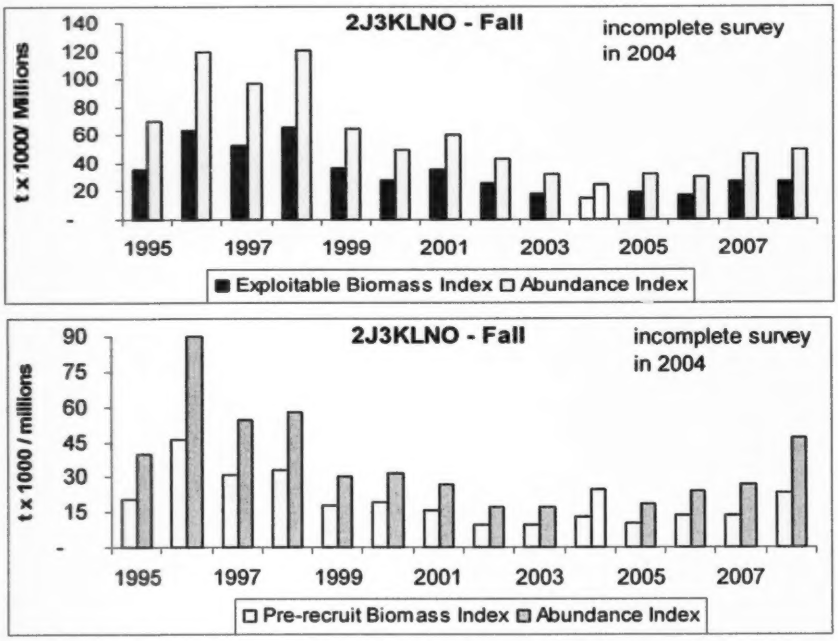


Figure 8. Trends in the fall trawl survey exploitable biomass and abundance indices (above) and pre-recruit biomass and abundance indices (bottom), for Division 2J3KLNO.

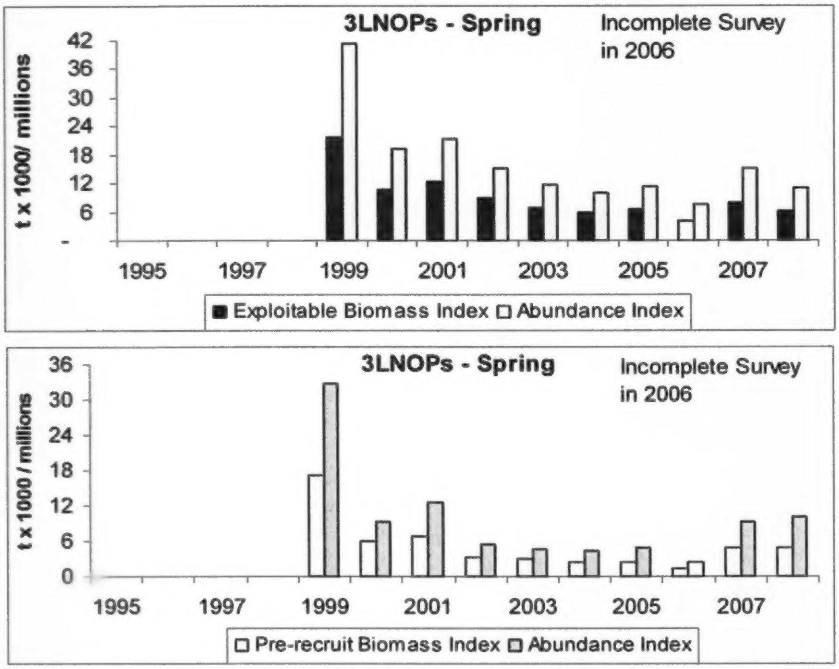


Figure 9. Trends in the spring trawl survey exploitable biomass and abundance indices (above) and pre-recruit biomass and abundance indices (below), for Division 3LNOPs.

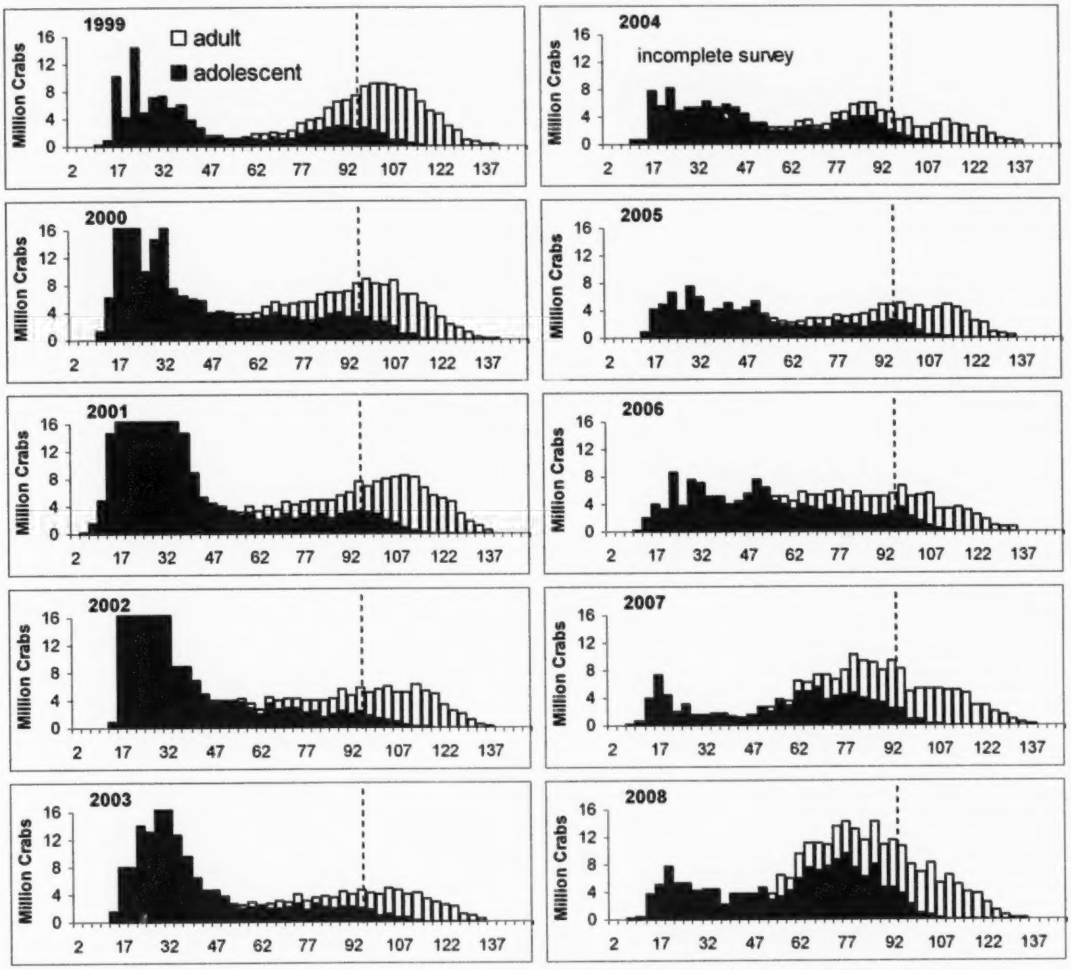


Figure 10. Distribution of abundance (index) by carapace width for Division 2J3KLNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (<50 mm CW). The minimum legal size is indicated by a vertical dashed line.

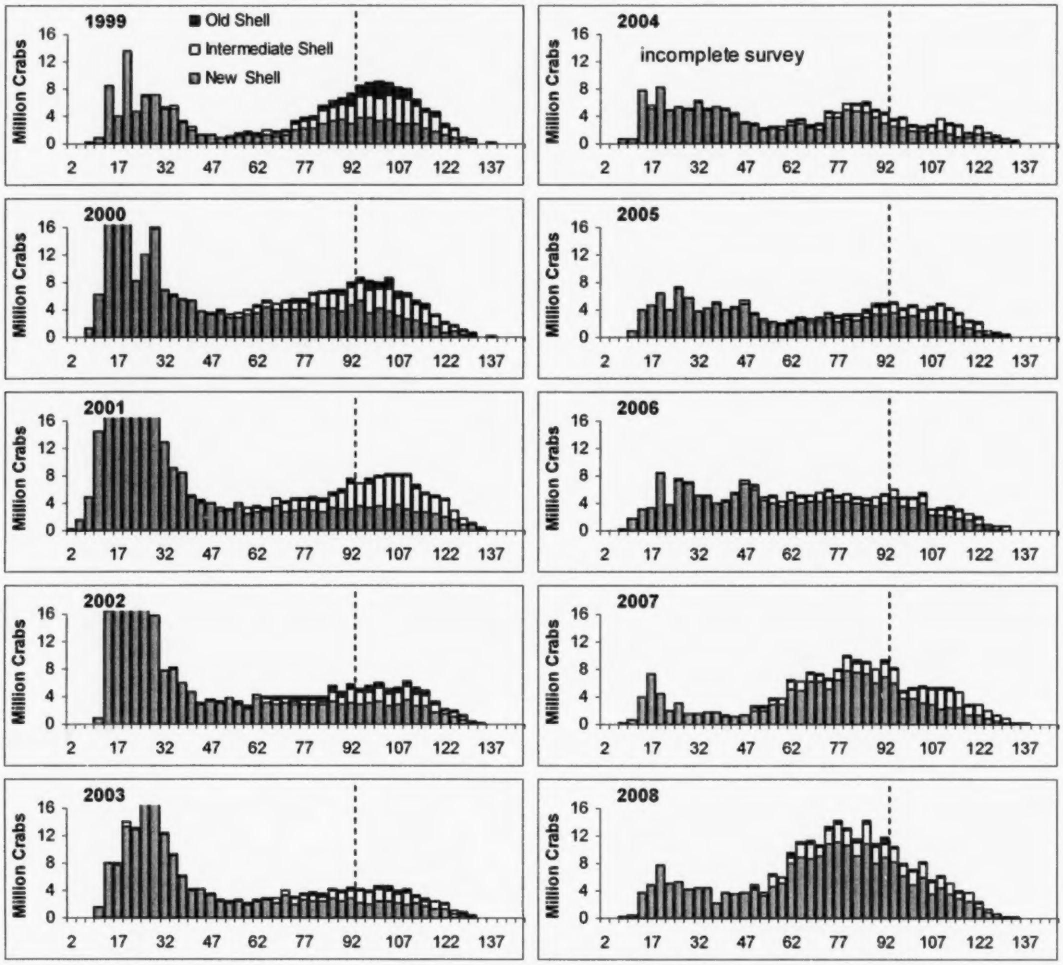


Figure 11. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 2J3KLNO. Abundance is truncated for smallest crabs (<50 mm CW). The minimum legal size is indicated by a vertical dashed line.

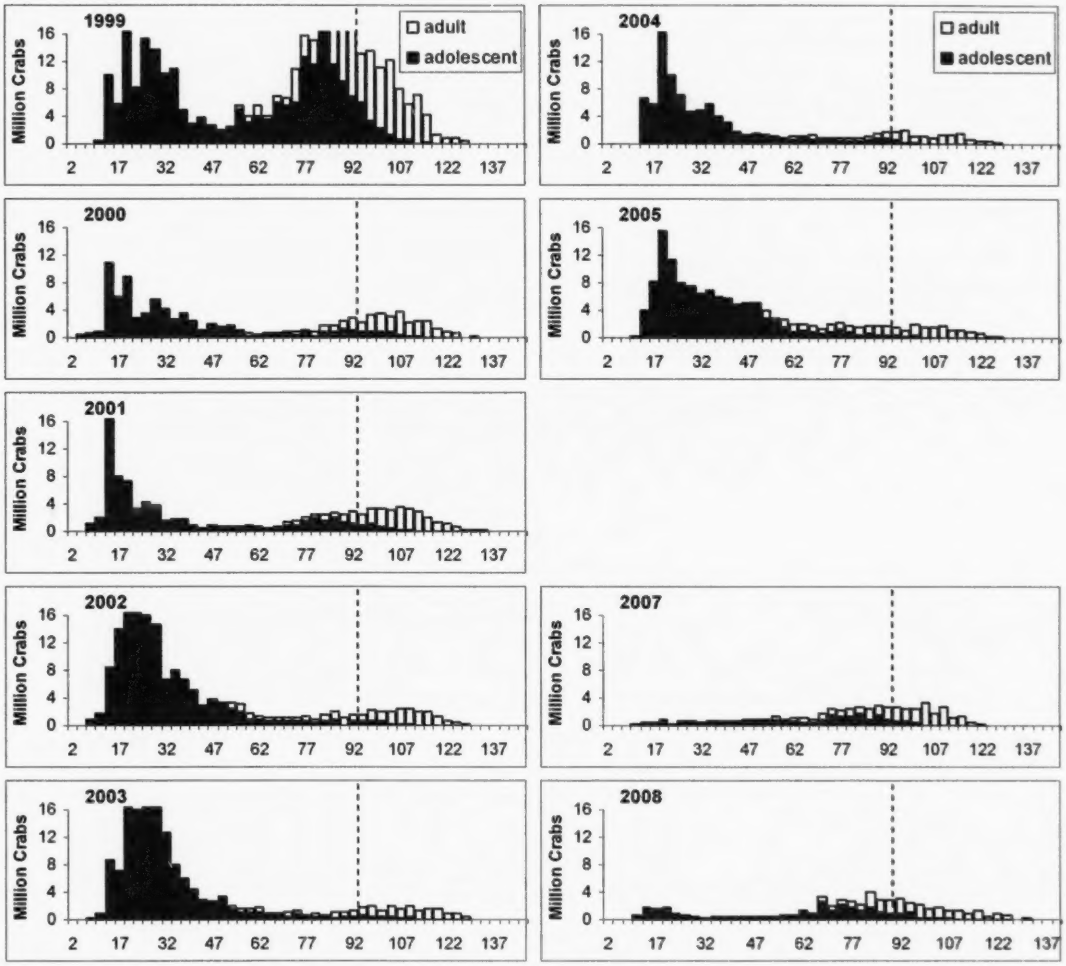


Figure 12. Distribution of abundance (index) by carapace width for Division 3LNOPs juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

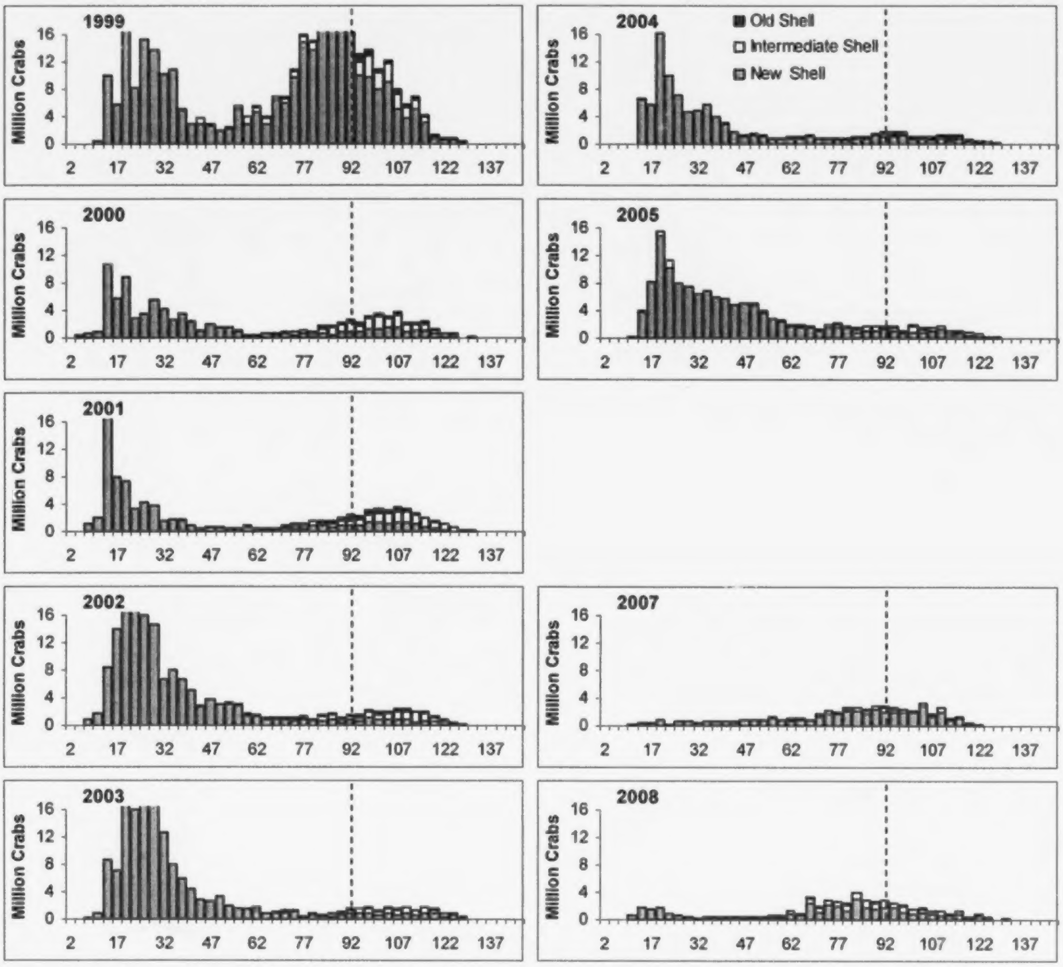
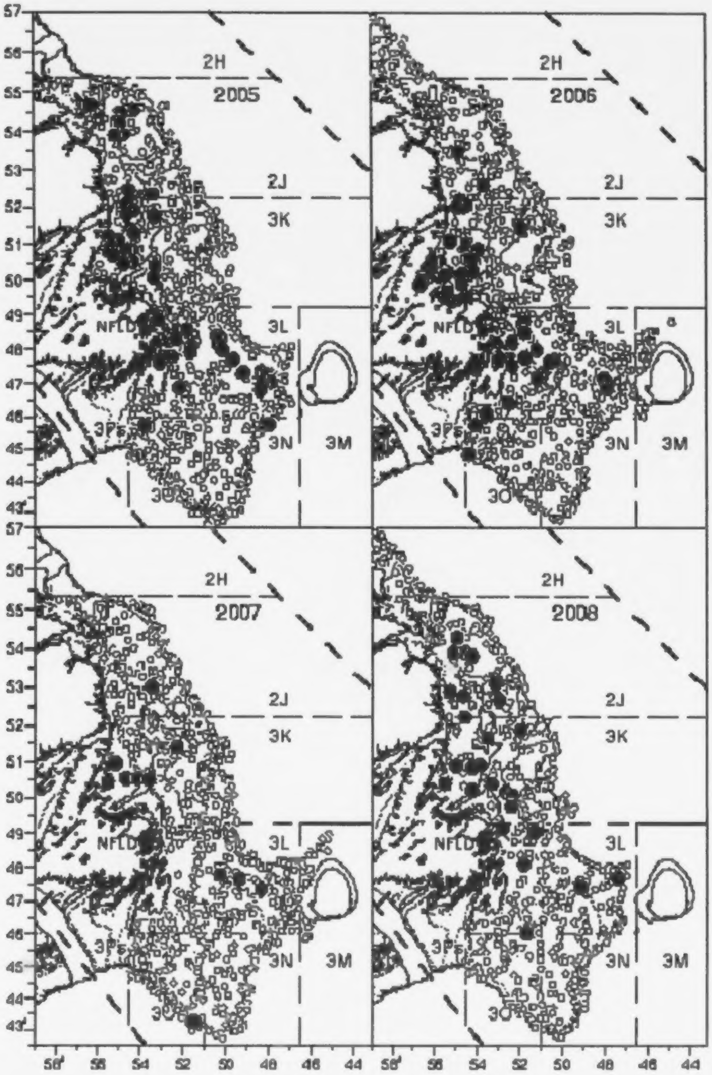


Figure 13. Distribution of abundance (index) by carapace width and shell condition from spring trawl surveys for Division 3LNOPs. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.


2H
2005
2J
3K
3L
NFLD
3Ps
3N
3M
3O
2006
2007
2008
57
56
55
54
53
52
51
50
49
48
47
46
45
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44

Figure 14. Distribution by year of fall trawl survey sets where BCD was encountered (closed circles) versus all other sets (open circles) from 2005 to 2008.

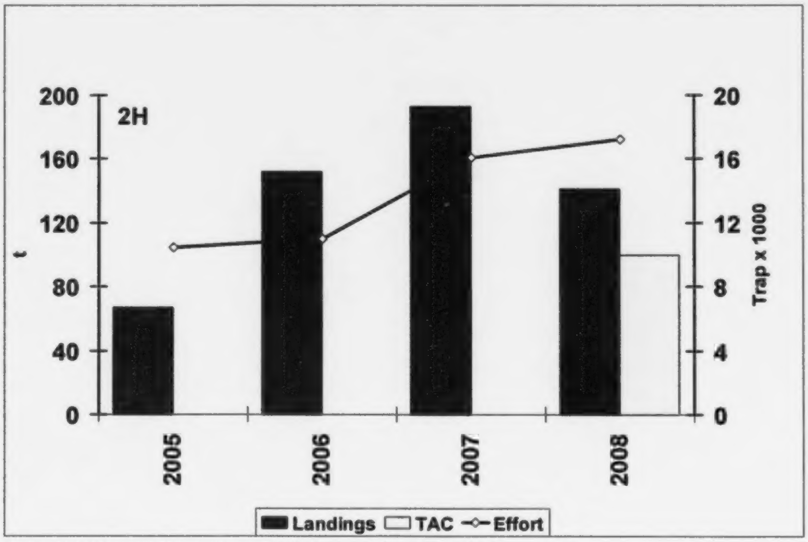


Figure 15. Trends in Division 2H landings, TAC, and fishing effort.

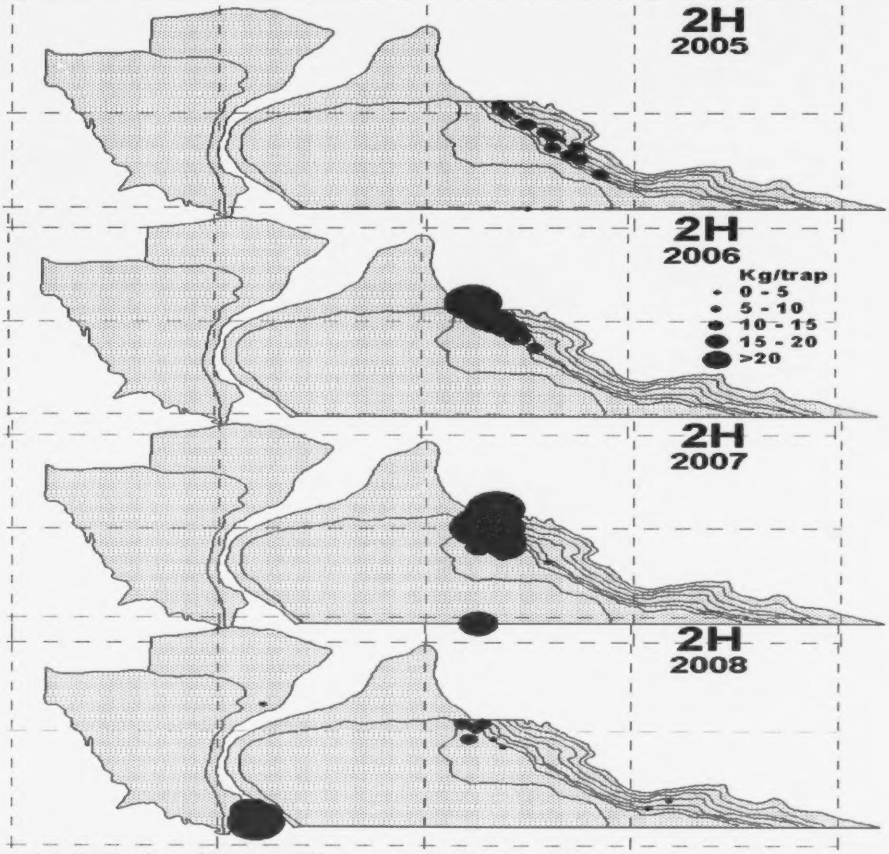

2H
2005
2H
2006
Kg/trap
0 - 5
5 - 10
10 - 15
15 - 20
>20
2H
2007
2H
2008

Figure 16. Spatial distribution of Division 2H commercial CPUE by year.

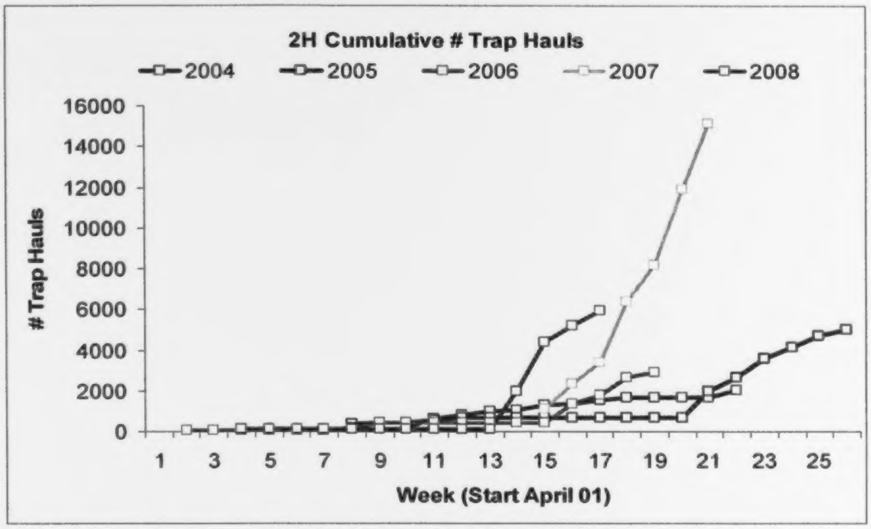


Figure 17. Seasonal trends in fishing effort for Division 2H during 2004-08.

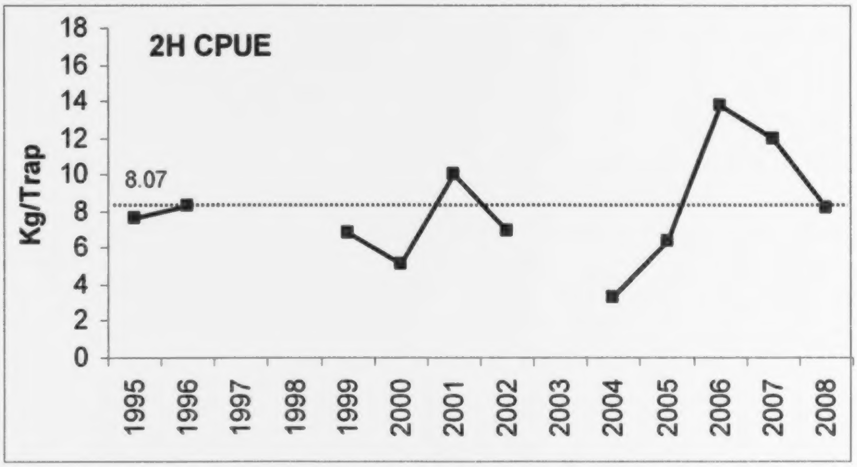


Figure 18. Trends in Division 2H commercial CPUE in relation to the long-term average (dotted line).

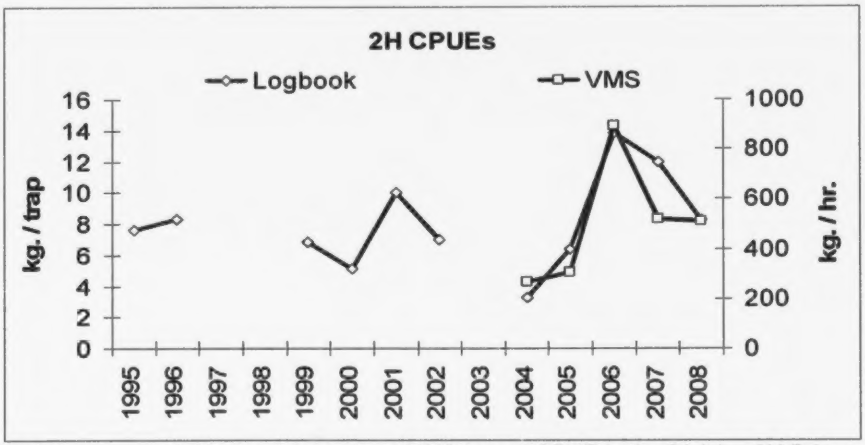


Figure 19. Trends in commercial logbook-based and VMS-based CPUE in the Division 2H fishery.

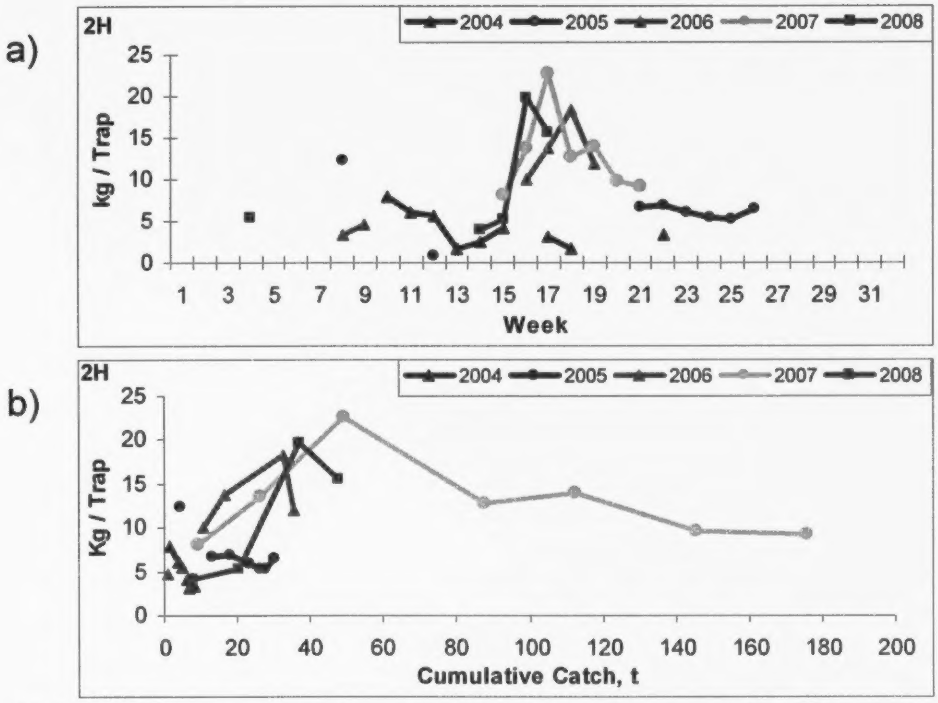


Figure 20. Seasonal trends in logbook-based CPUE for Division 2H during 2004-08; (a) by week, and (b) in relation to cumulative catch.

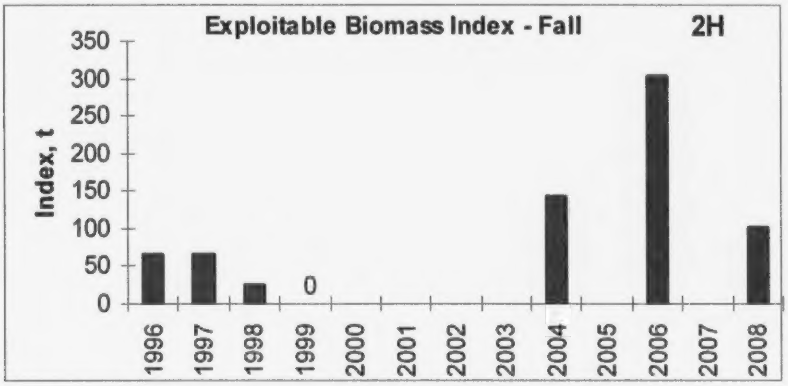
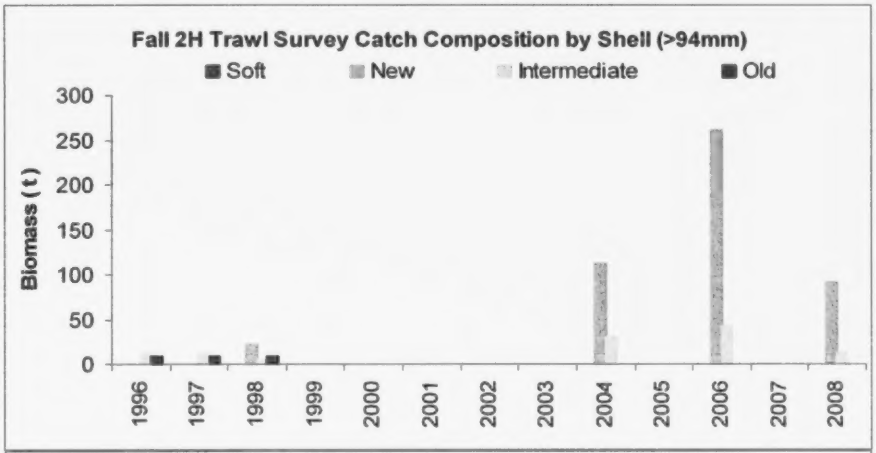


Figure 21. Trends in the Division 2H fall trawl survey exploitable biomass index.

a)



b)

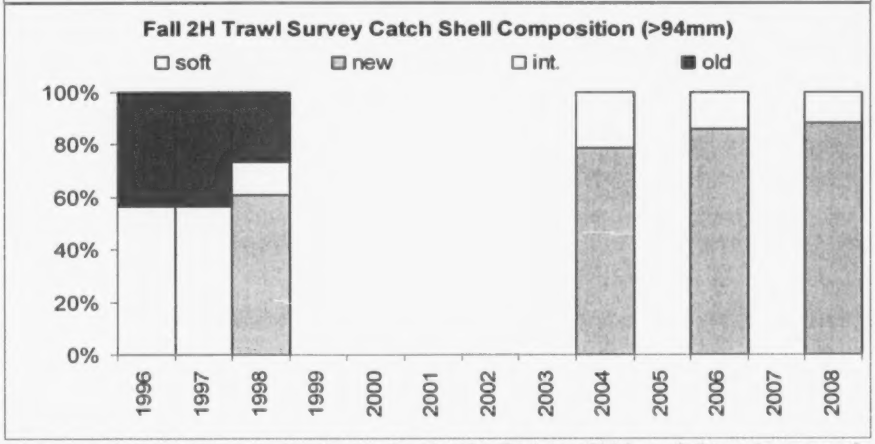


Figure 22. Trends, by shell condition, in legal-sized males for Division 2H from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

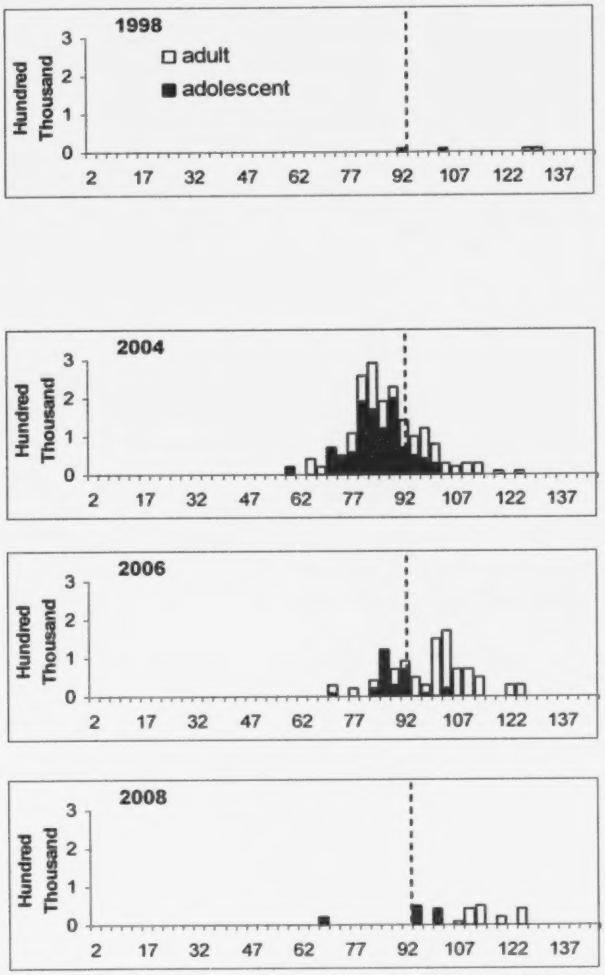


Figure 23. Distribution of abundance (index) by carapace width for Division 2H juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

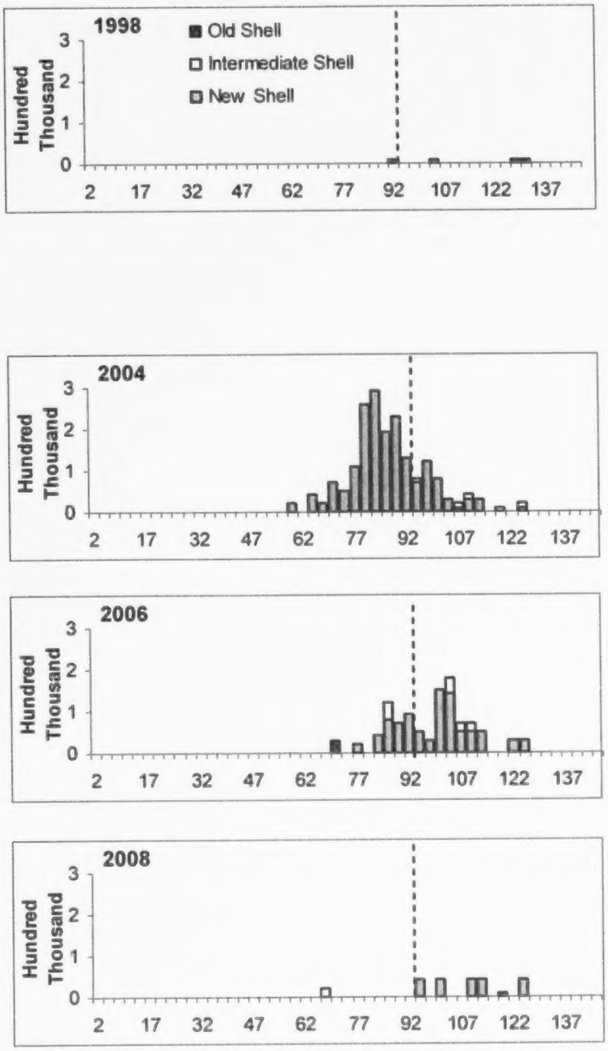


Figure 24. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 2H. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

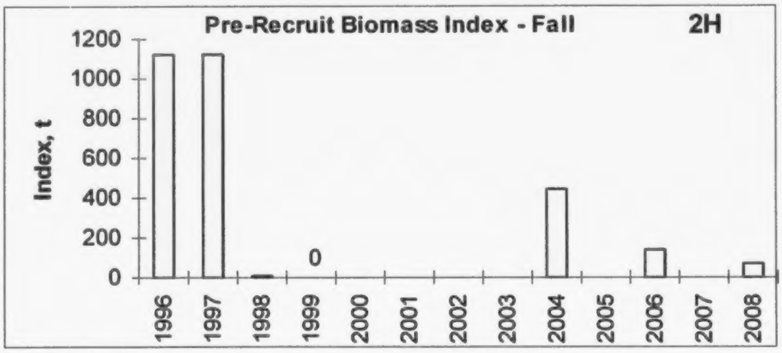


Figure 25. Trends in the Division 2H fall trawl survey pre-recruit biomass index.

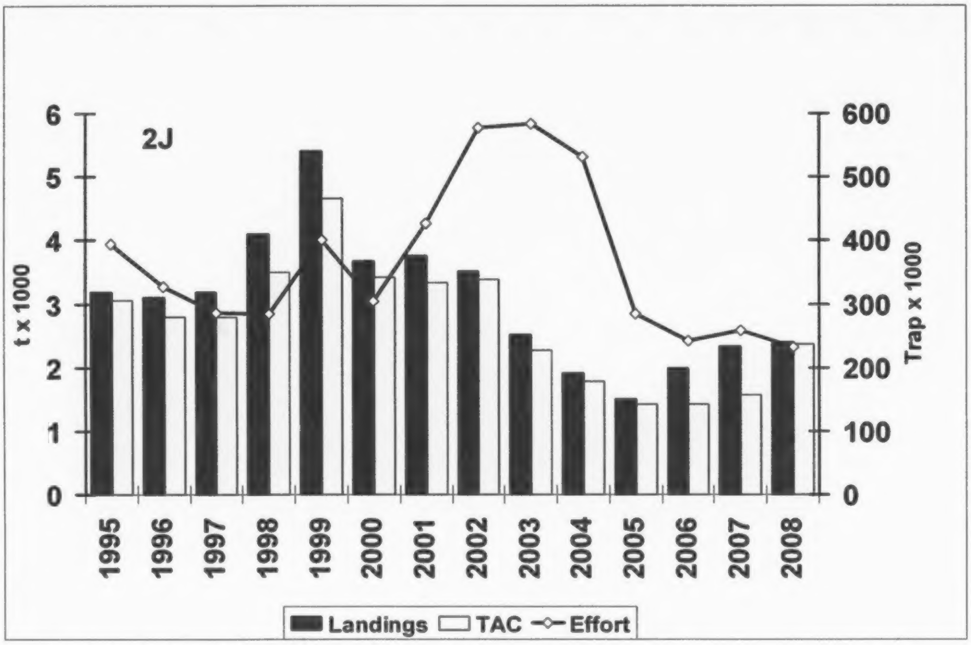


Figure 26. Trends in Division 2J landings, TAC, and fishing effort.

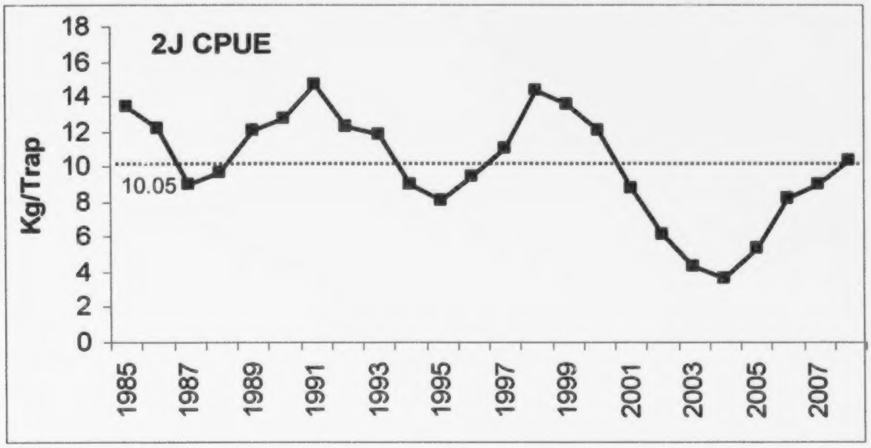


Figure 27. Trends in Division 2J commercial CPUE in relation to the long-term average (dotted line).

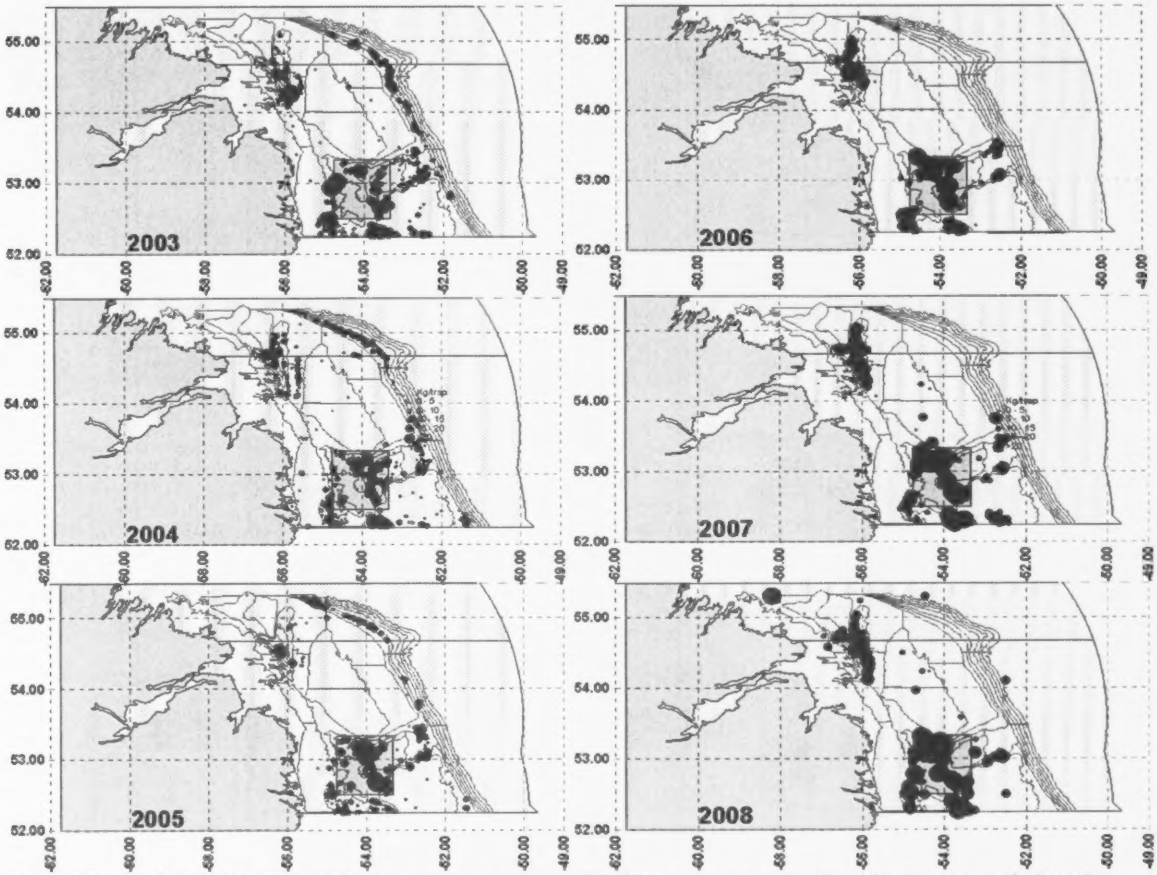

2003
2004
2005
2006
2007
2008
55.00
54.00
53.00
52.00
62.00
60.00
58.00
56.00
54.00
52.00
50.00
49.00
Kg/trap

Figure 28. Spatial distribution of Division 2J commercial CPUE by year showing the Hawke channel closed area.

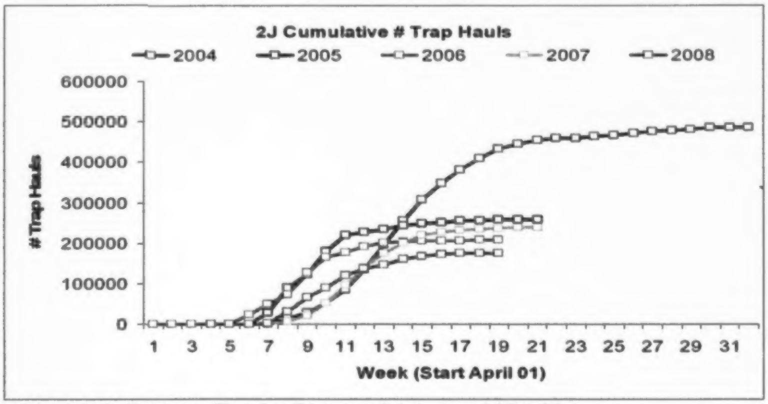


Figure 29. Seasonal trends in fishing effort for Division 2J during 2004-08.

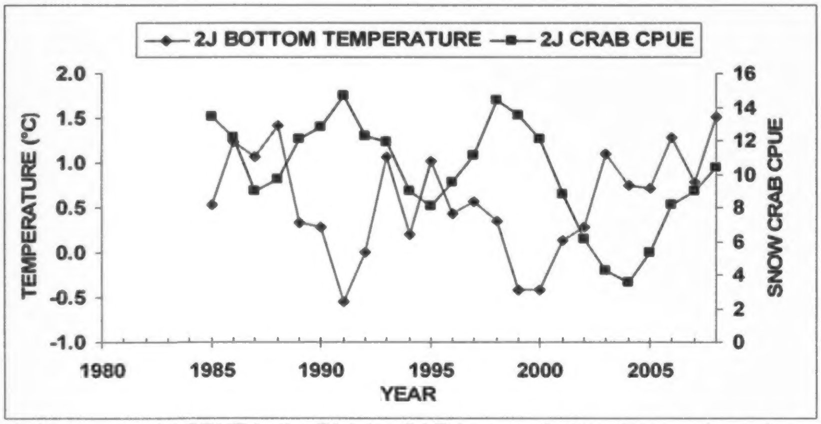


Figure 30. Trends in commercial CPUE in the Division 2J fishery vs. bottom temperature at a seven year lag.

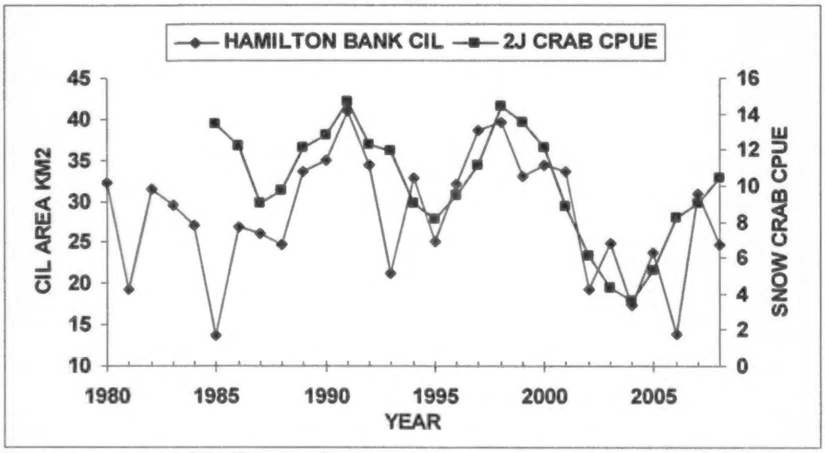


Figure 31. Trends in commercial CPUE in the Division 2J fishery vs. spatial extent of the cold intermediate layer at a seven year lag.

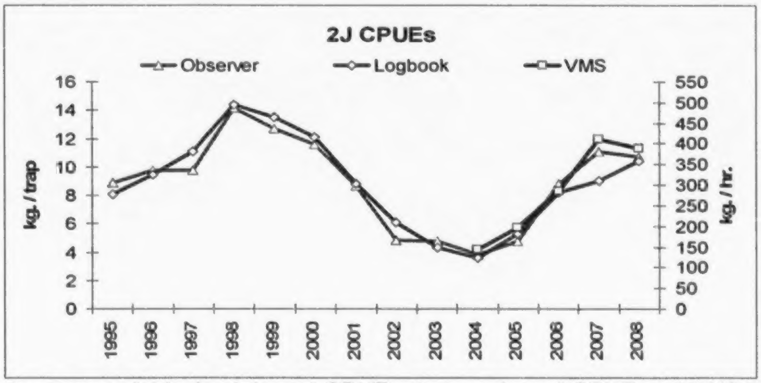


Figure 32. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 2J fishery.

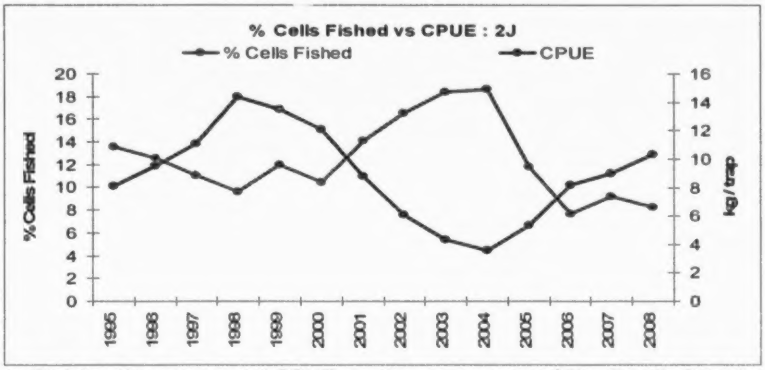


Figure 33. Trends in Division 2J commercial CPUE vs. the percentage of 5' x 5' cells fished.

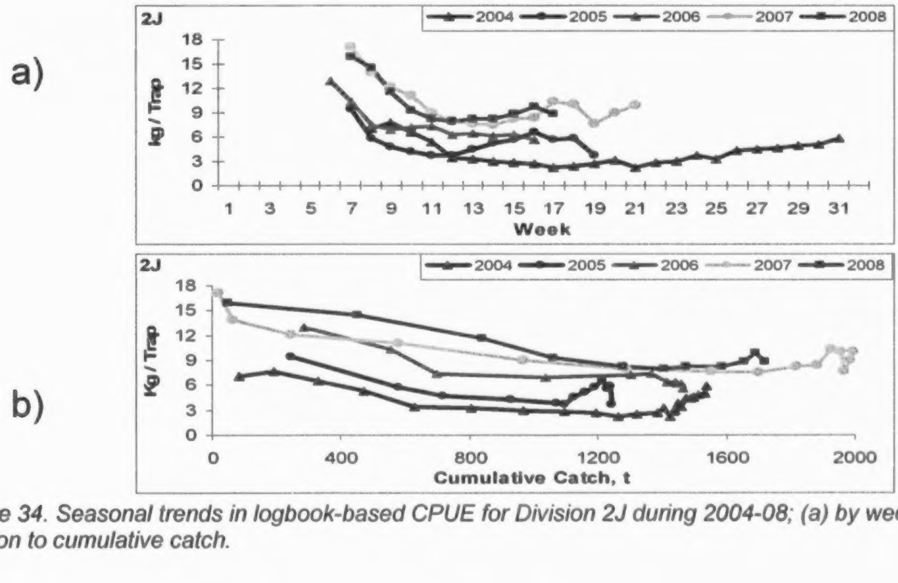


Figure 34. Seasonal trends in logbook-based CPUE for Division 2J during 2004-08; (a) by week, and (b) in relation to cumulative catch.

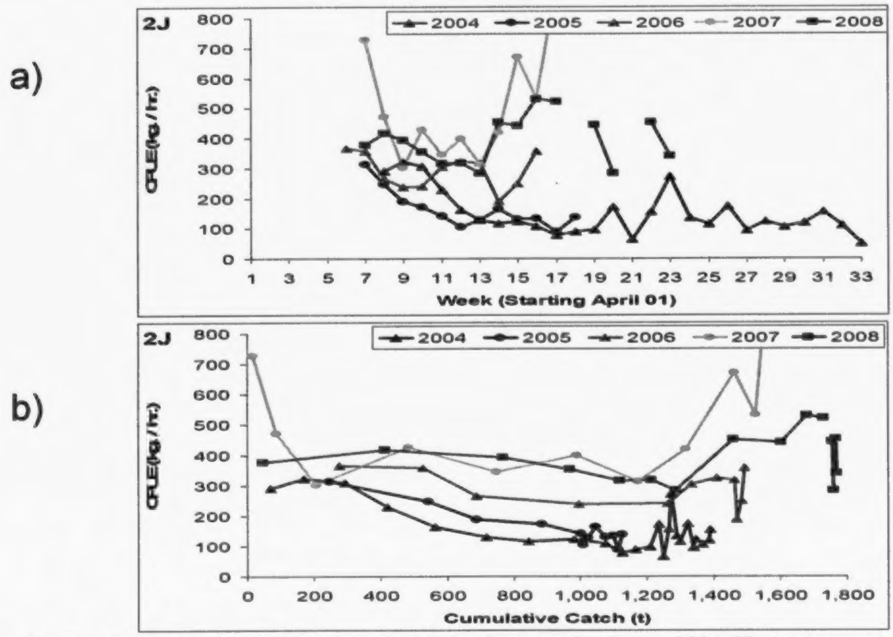


Figure 35. Seasonal trends in VMS-based CPUE for Division 2J during 2004-08; (a) by week, and (b) in relation to cumulative catch.

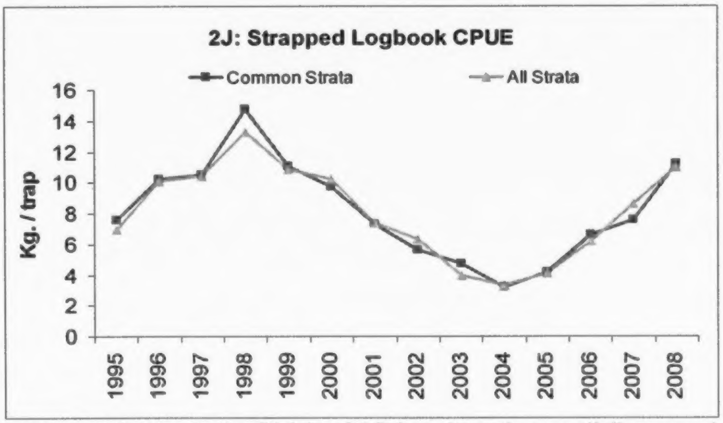


Figure 36. Trends in mean catch rates in the Division 2J fishery based on spatially-expanded logbook STRAP analysis.

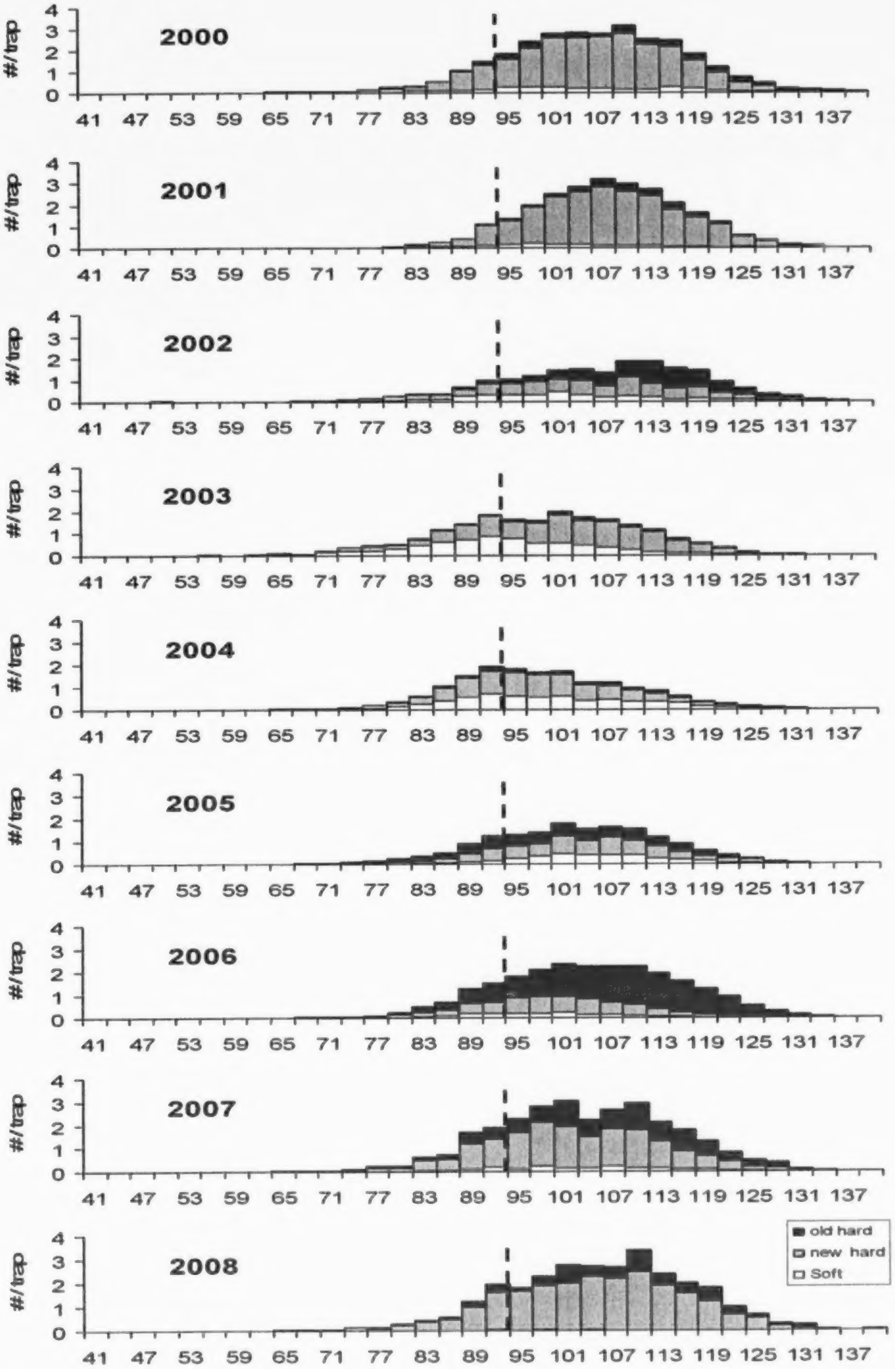


Figure 37. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 2J. The vertical dashed line indicates the minimum legal size.

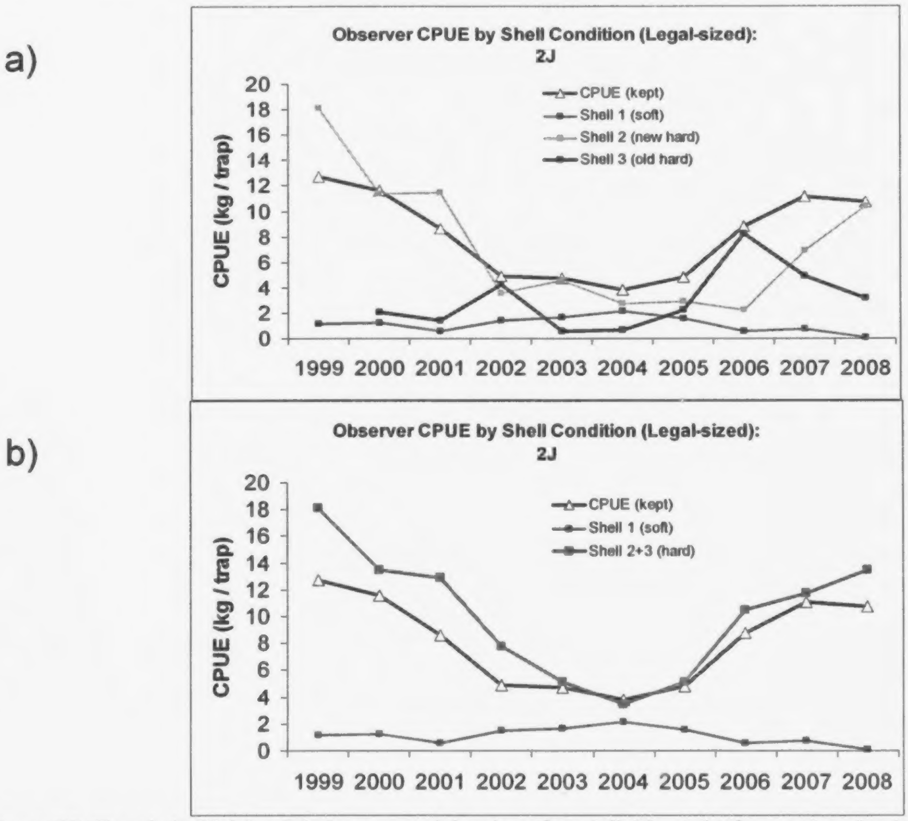


Figure 38. Trends in Division 2J observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

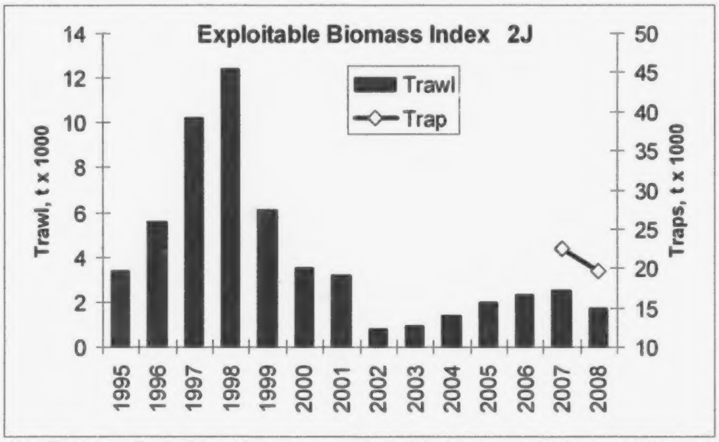


Figure 39. Trends in the Division 2J fall trawl survey exploitable biomass index and the post-season survey biomass index.

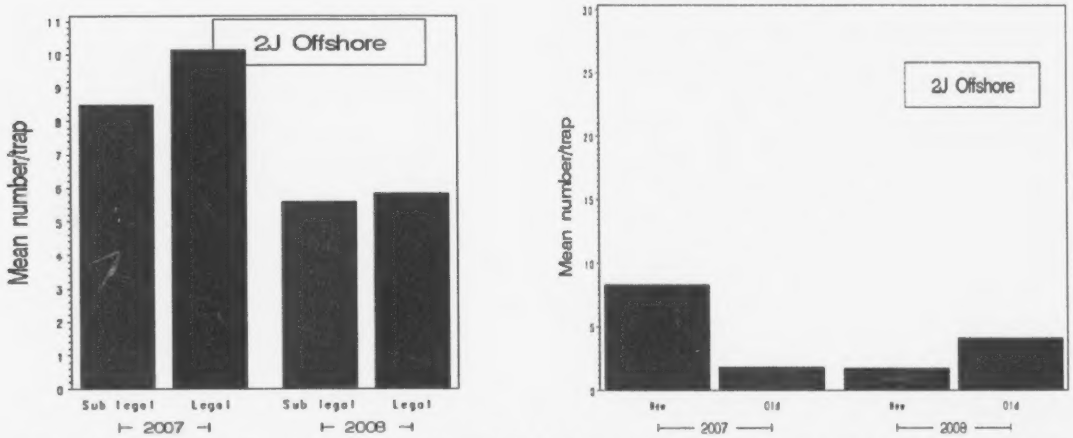


Figure 40. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 2J industry-DFO collaborative post-season trap survey.

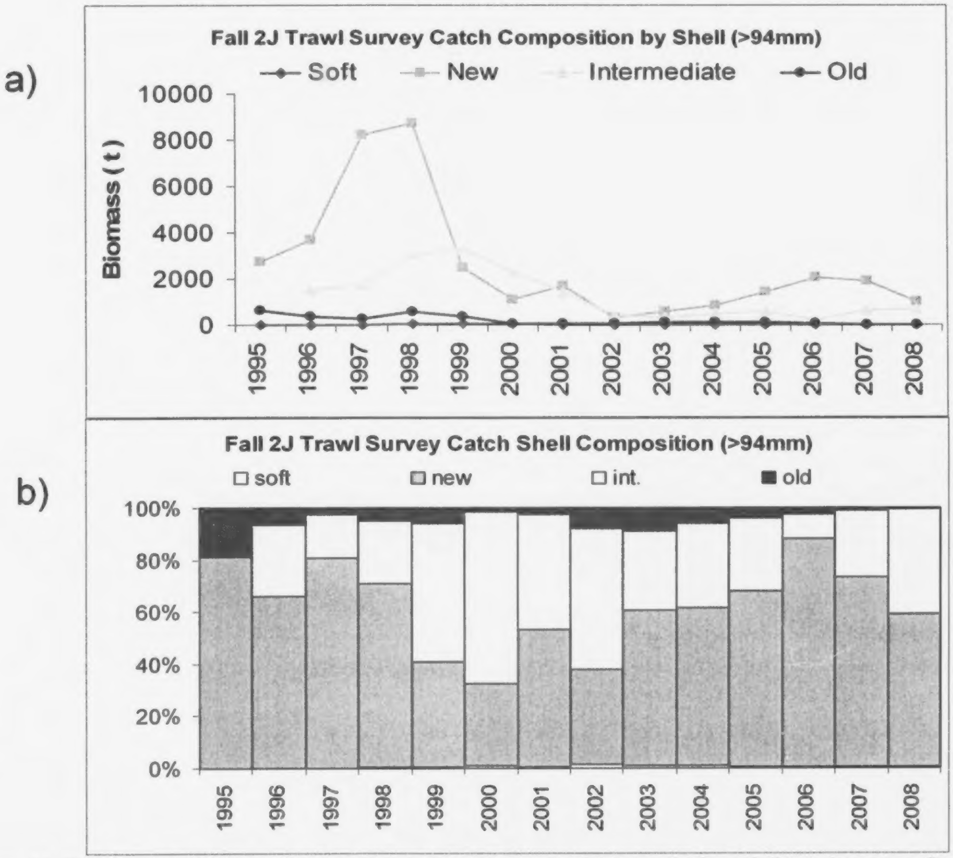


Figure 41. Trends, by shell condition, in legal-sized males for Division 2J from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

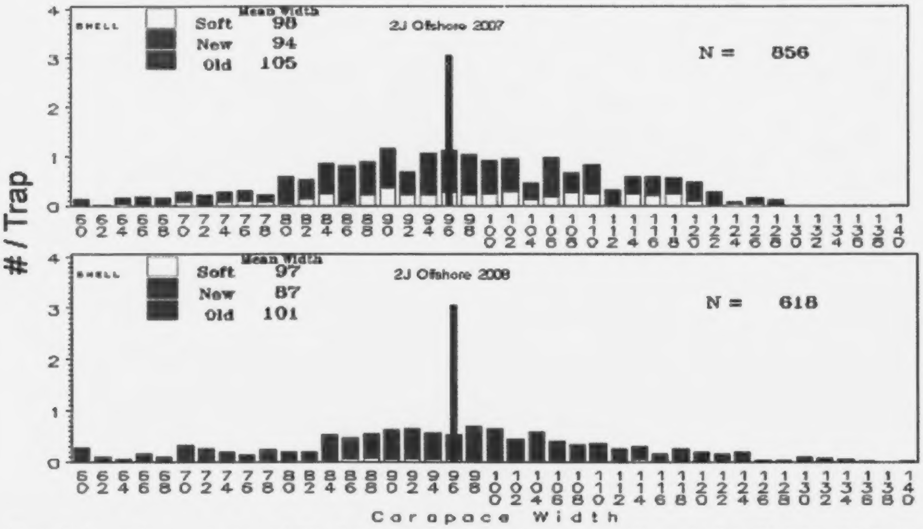


Figure 42. Trends in male carapace width distributions from common stations in the Division 2J industry-DFO collaborative post-season trap survey. The vertical solid line indicates the minimum legal size.

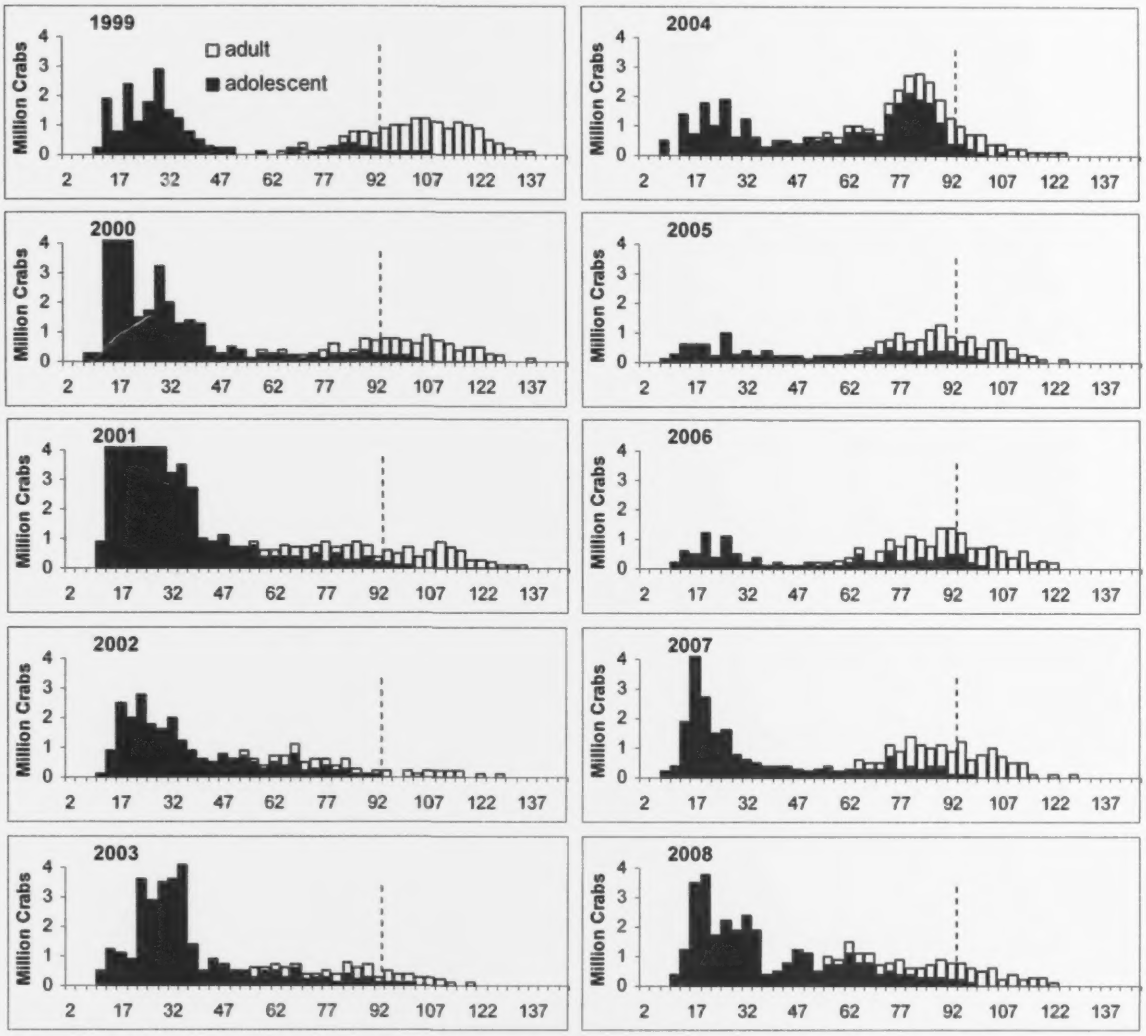


Figure 43. Distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

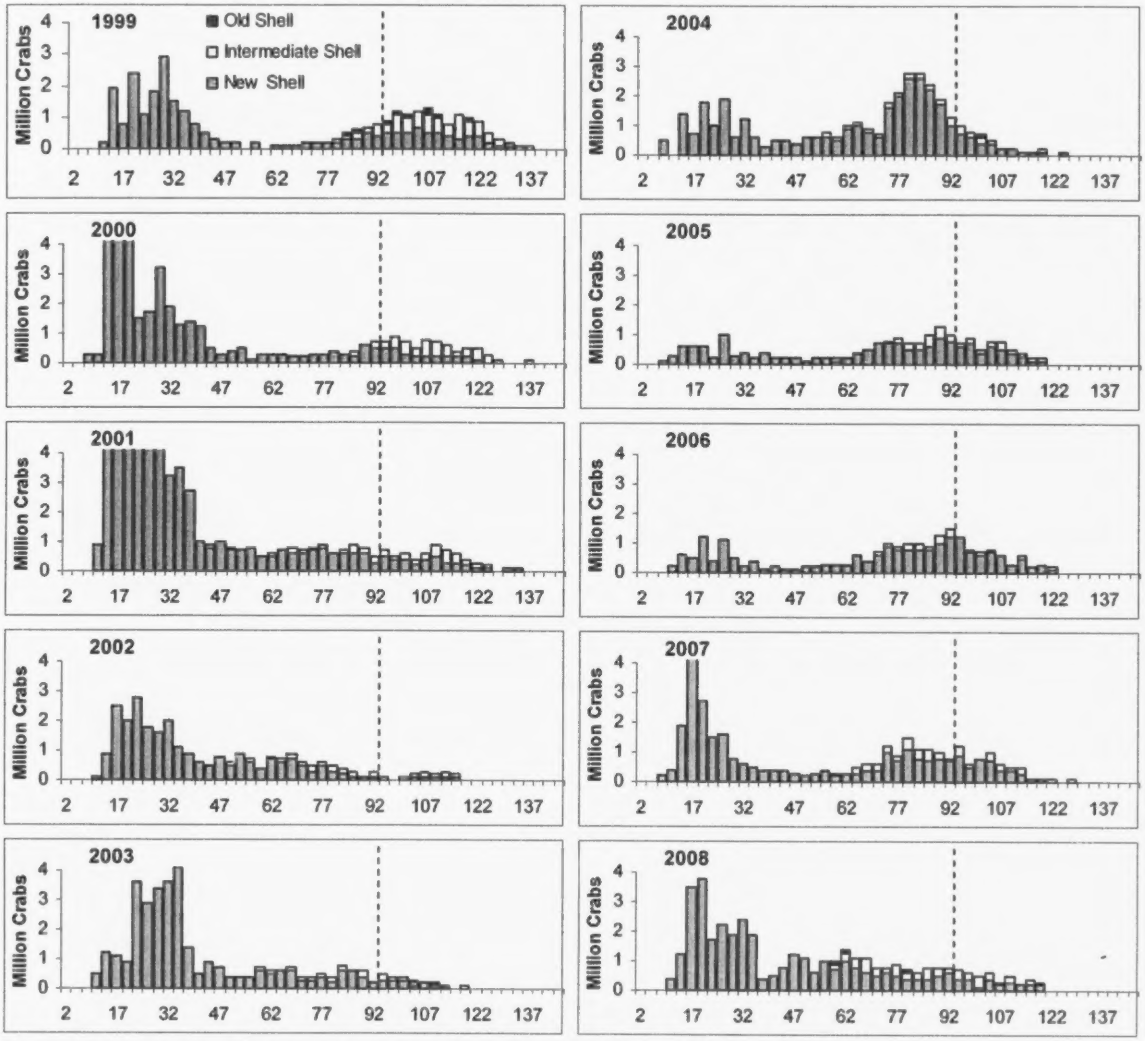


Figure 44. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 2J. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

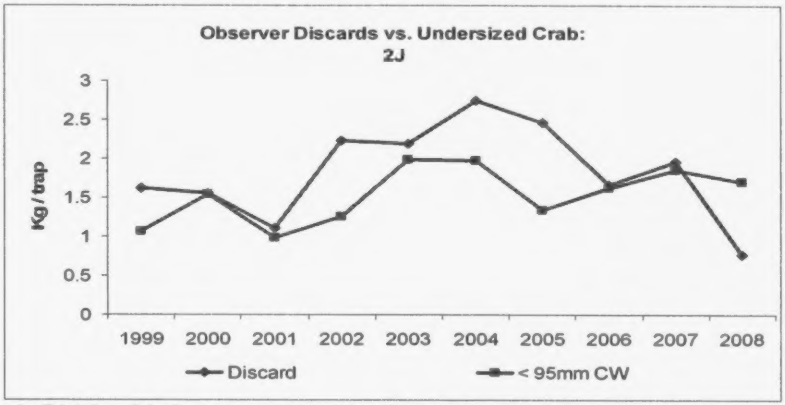


Figure 45. Trends in Division 2J observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

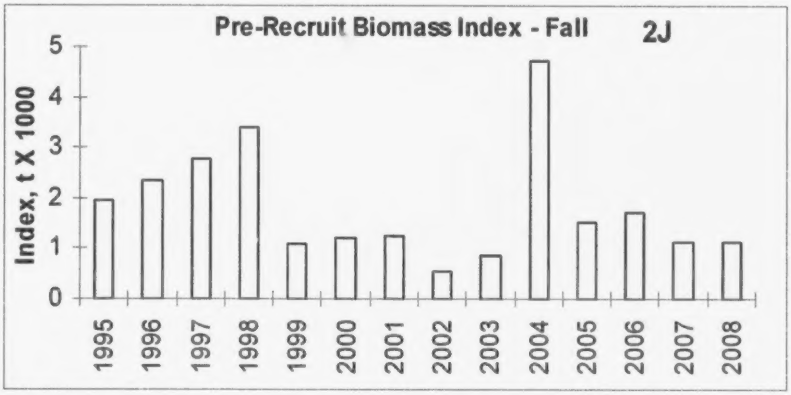


Figure 46. Trends in the Division 2J fall trawl survey pre-recruit biomass index.

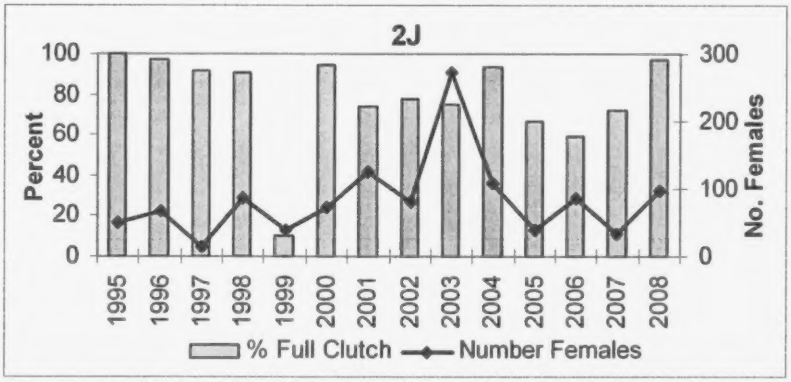


Figure 47. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 2J from fall multi-species surveys.

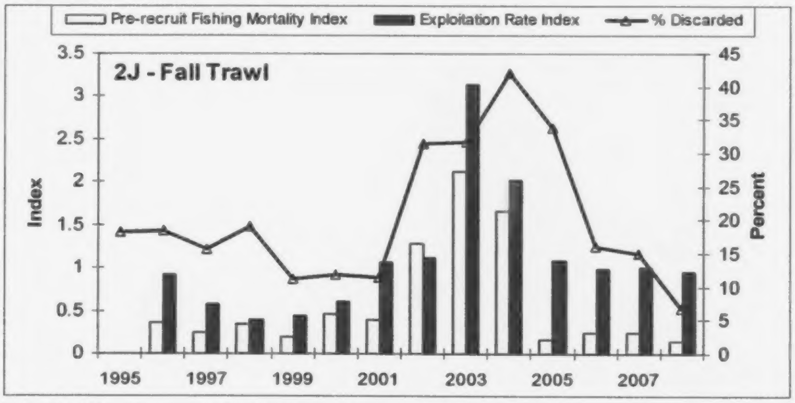


Figure 48. Trends in Division 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

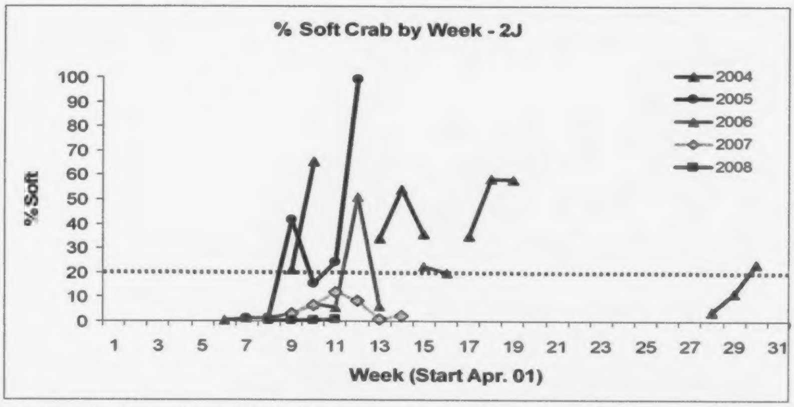


Figure 49. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 2J fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers (Sample sizes of <10 observed sets/week removed).

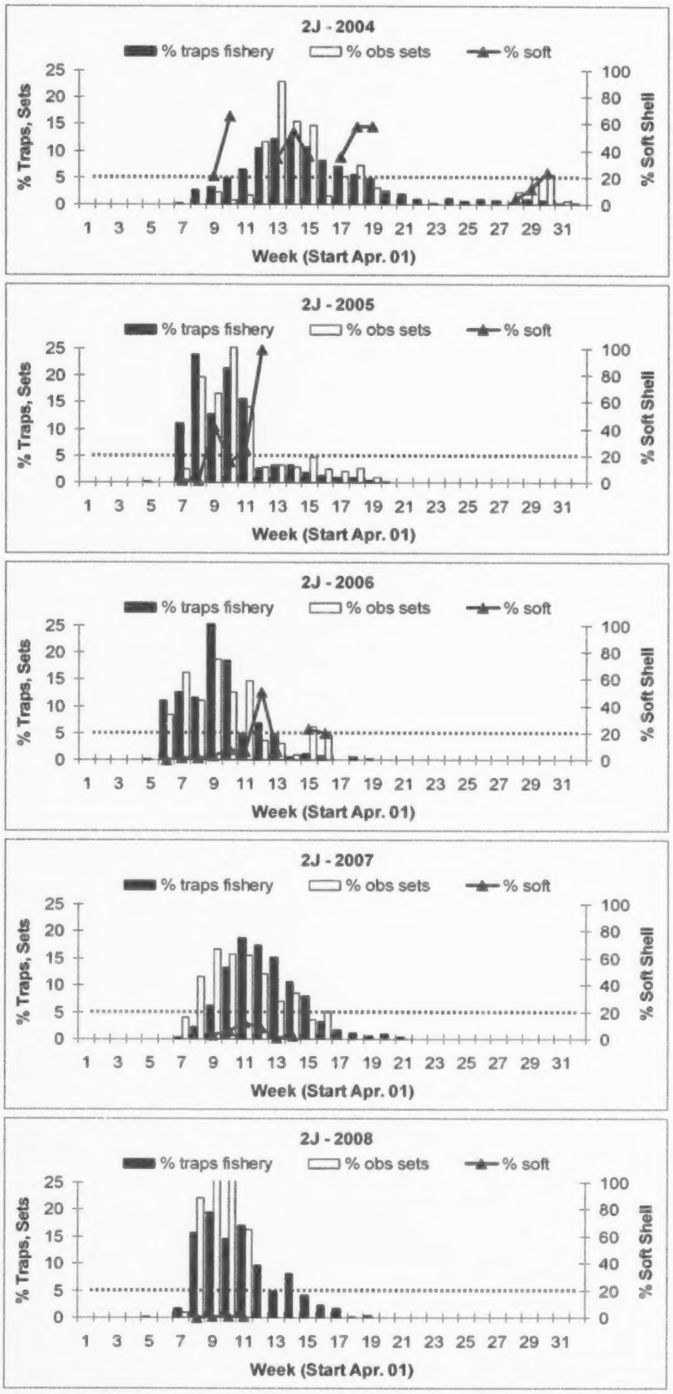


Figure 50. Seasonal trends in Division 2J distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2004-08. (Sample sizes of <10 observed sets/week removed)

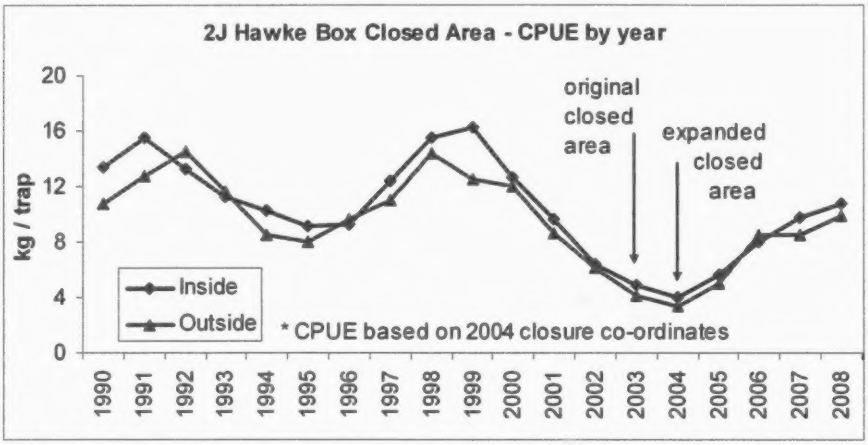


Figure 51. Division 2J commercial CPUE; inside vs. outside the Hawke Channel closed area.

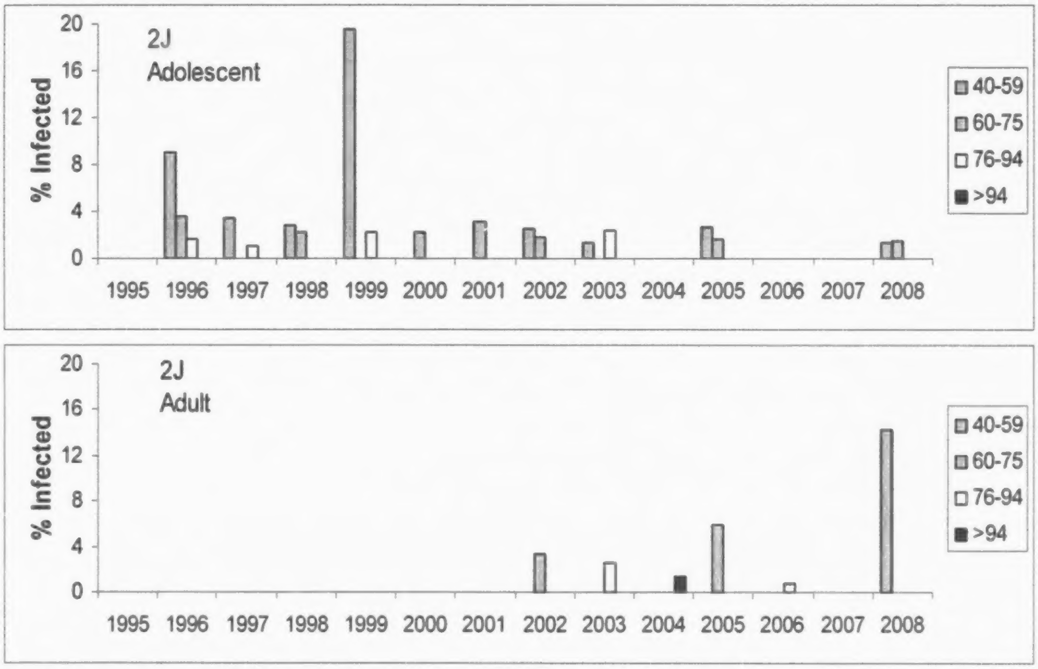


Figure 52. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 2J fall trawl surveys.

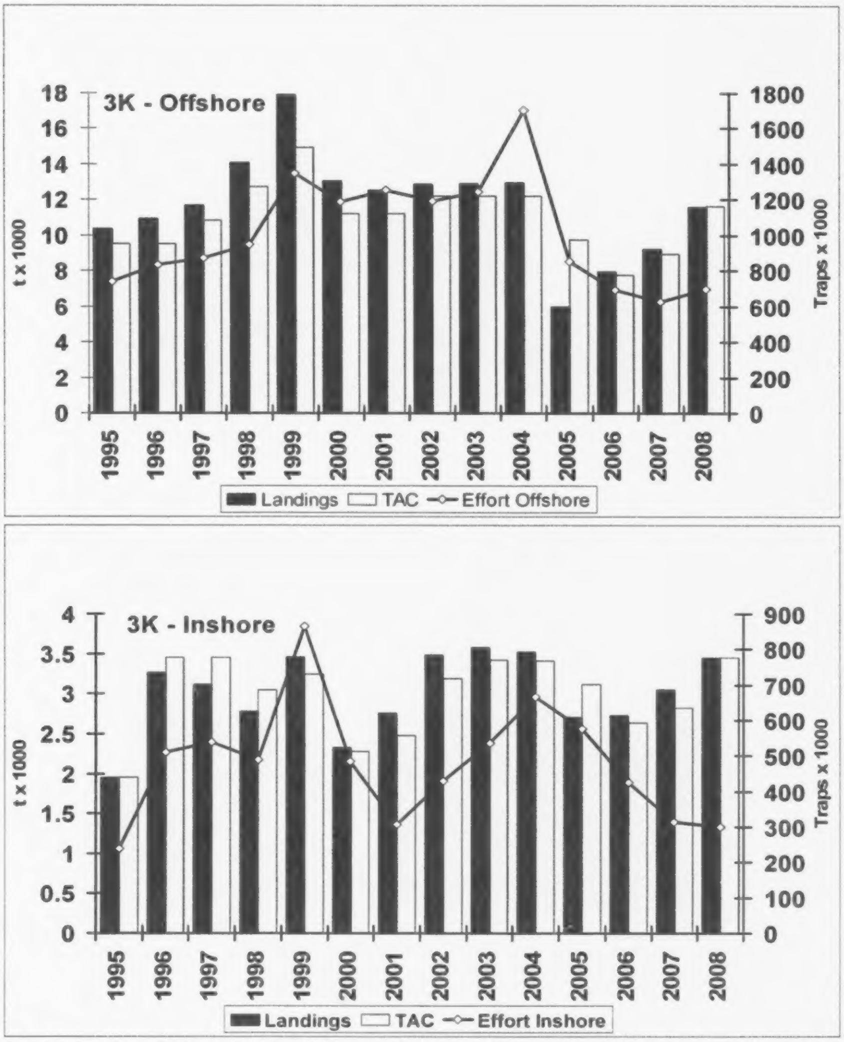


Figure 53. Trends in Division 3K landings, TAC, and fishing effort for the offshore (above) and inshore (below).

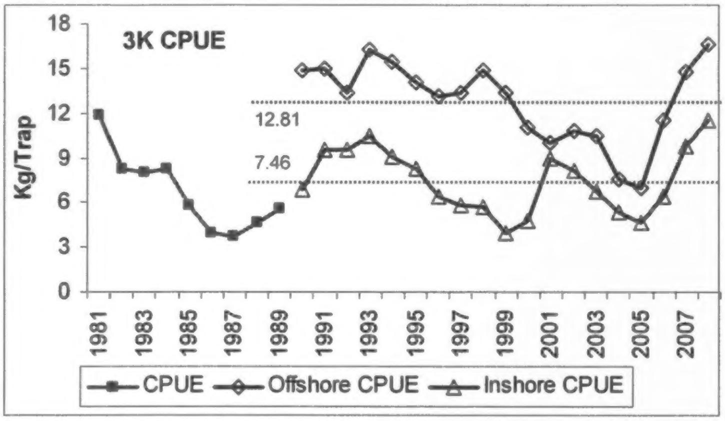


Figure 54. Trends in Division 3K offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

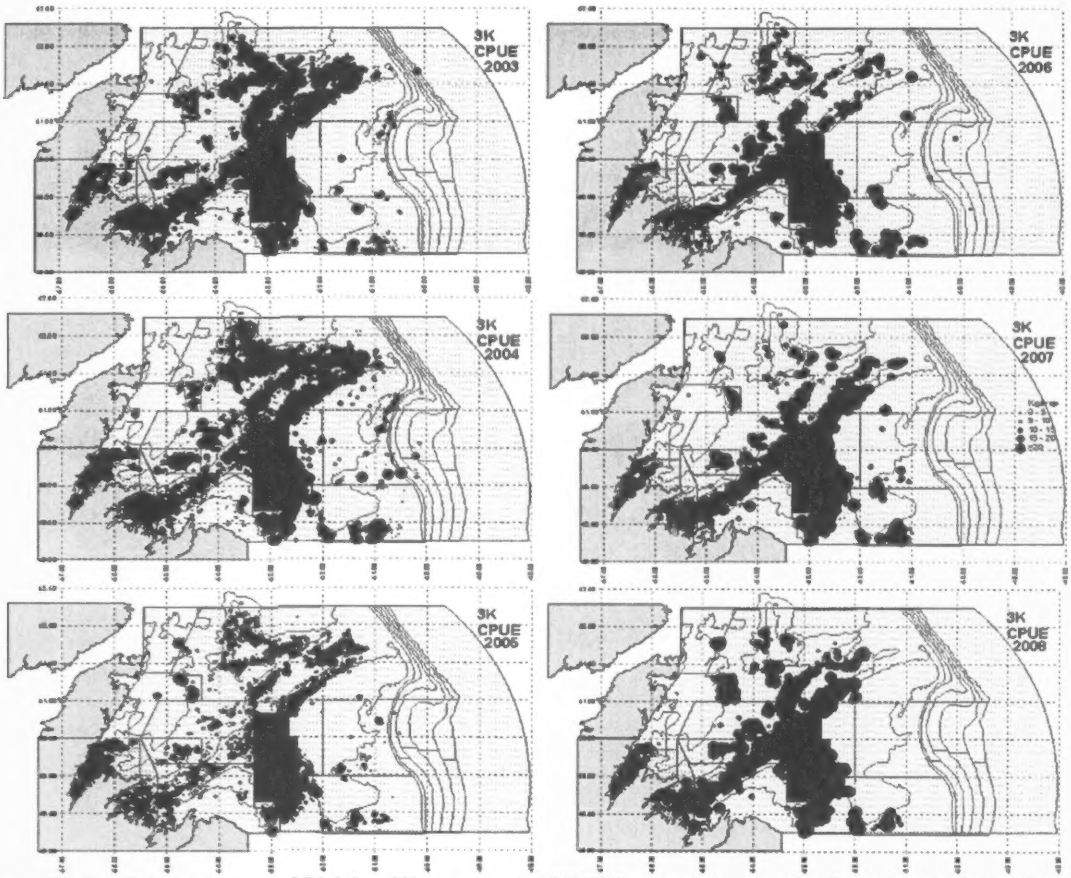

3K CPUE 2003
3K CPUE 2006
3K CPUE 2004
3K CPUE 2007
3K CPUE 2005
3K CPUE 2008

Figure 55. Spatial distribution of Division 3K commercial CPUE by year showing the Funk Island Deep closed area.

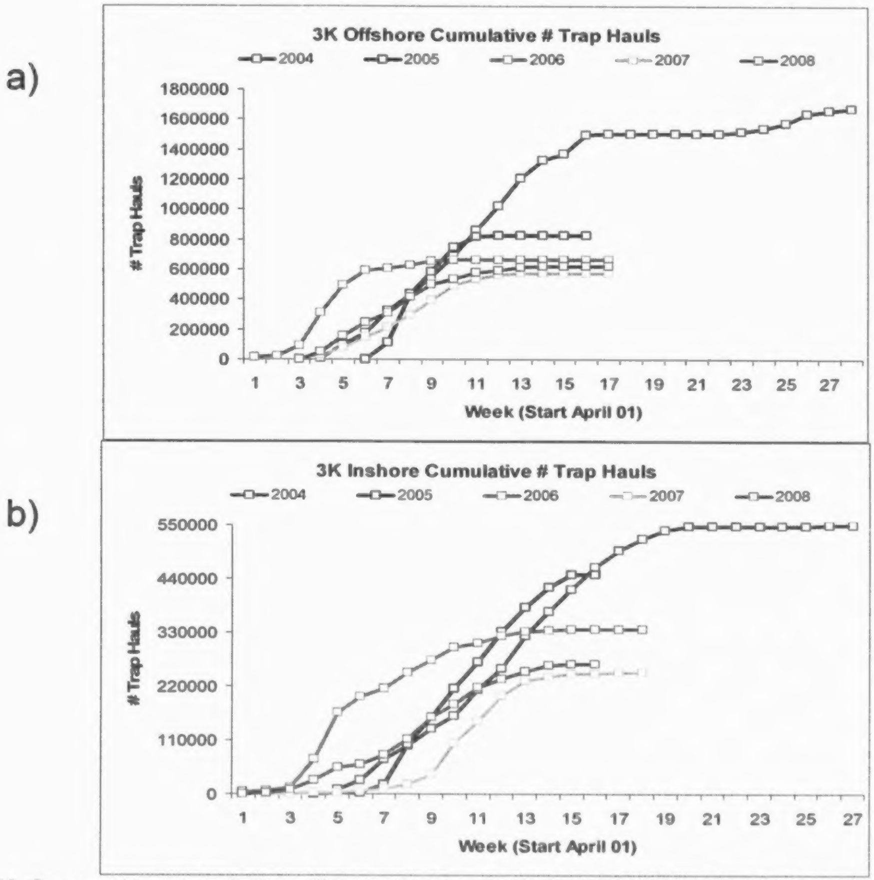


Figure 56. Seasonal trends in fishing effort for Division 3K during 2004-08 for (a) the offshore and (b) the inshore.

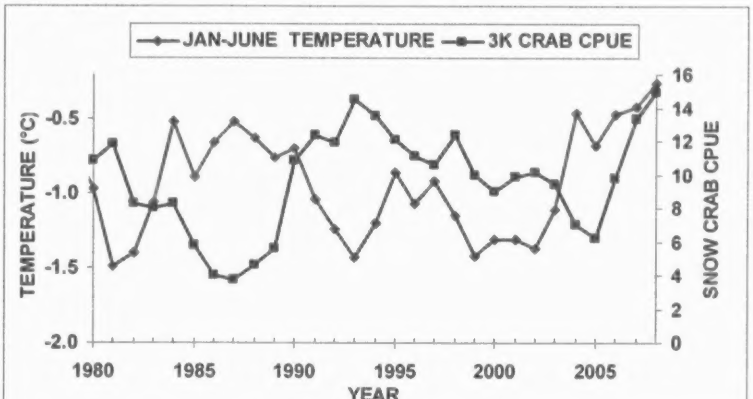


Figure 57. Trends in commercial CPUE in the Division 3K fishery (offshore and inshore combined) vs. Station 27 bottom temperature at an eight year lag.

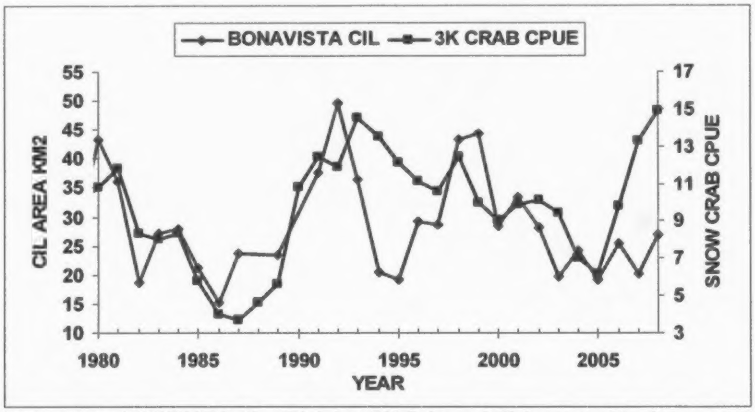


Figure 58. Trends in commercial CPUE in the Division 3K fishery (offshore and inshore combined) vs. spatial extent of the cold intermediate layer at an eight year lag.

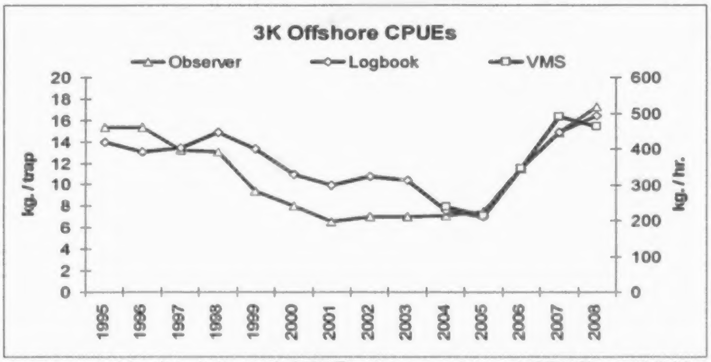


Figure 59. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3K offshore fishery.

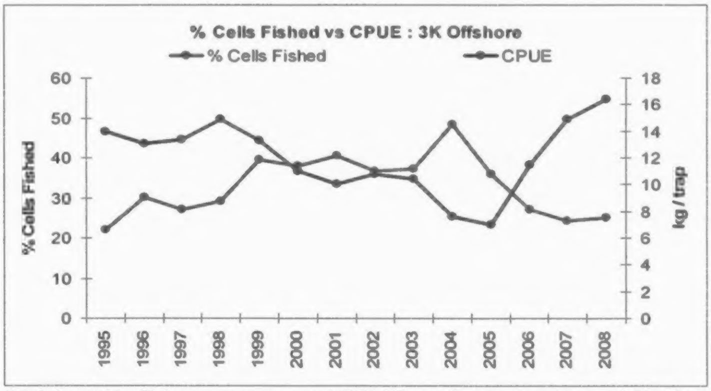


Figure 60. Trends in Division 3K offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

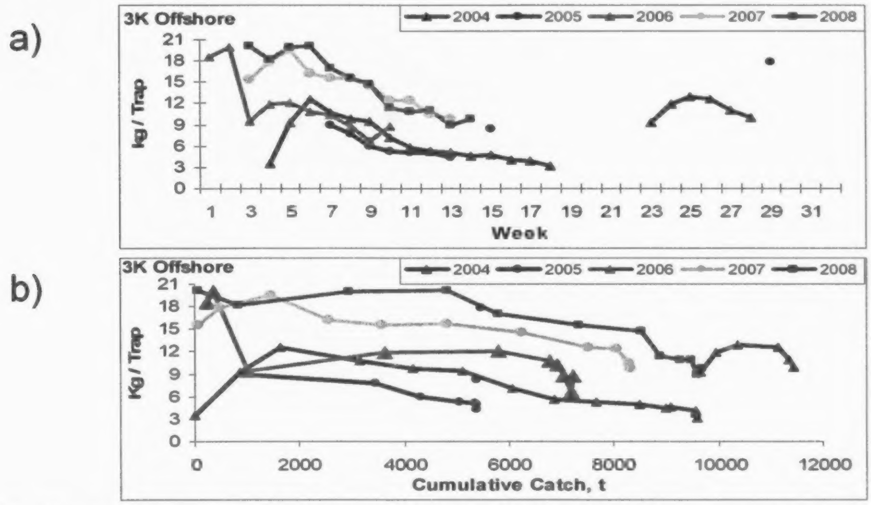


Figure 61. Seasonal trends in logbook-based CPUE for Division 3K offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

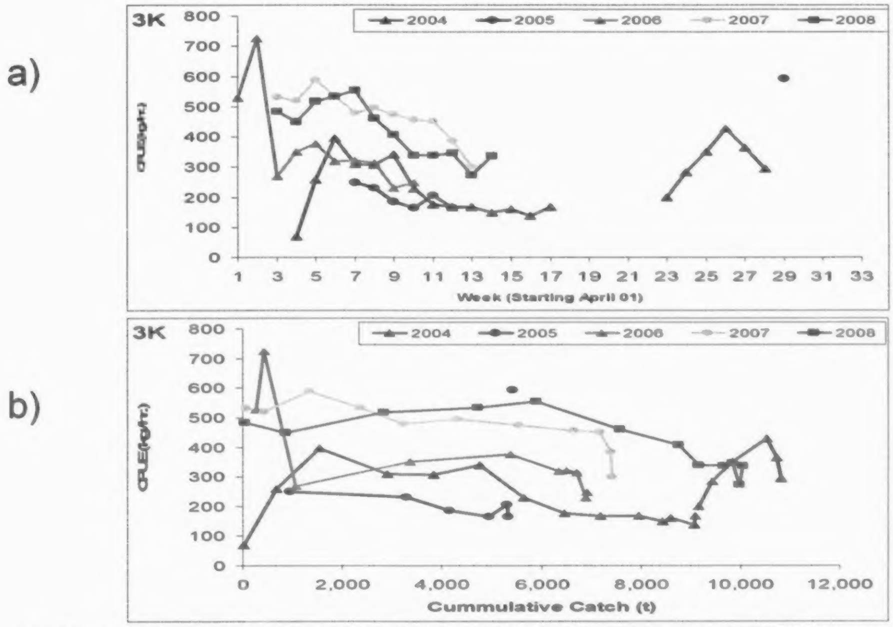


Figure 62. Seasonal trends in VMS-based CPUE for Division 3K offshore during 2002-08; (a) by week, and (b) in relation to cumulative catch.

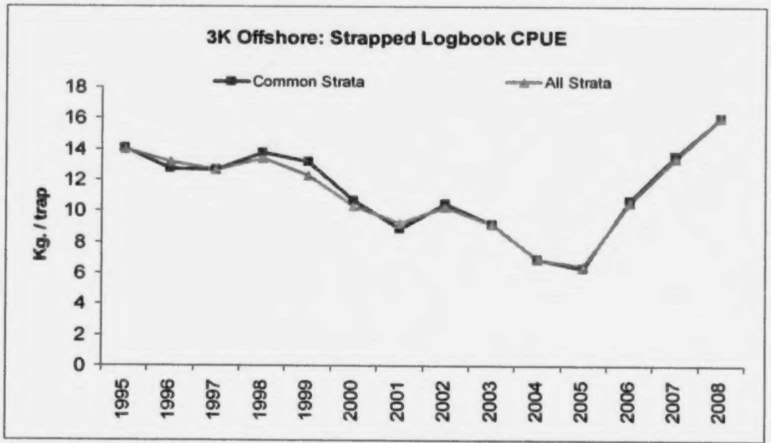


Figure 63. Trends in mean catch rates in the Division 3K offshore fishery based on spatially-expanded logbook STRAP analysis.

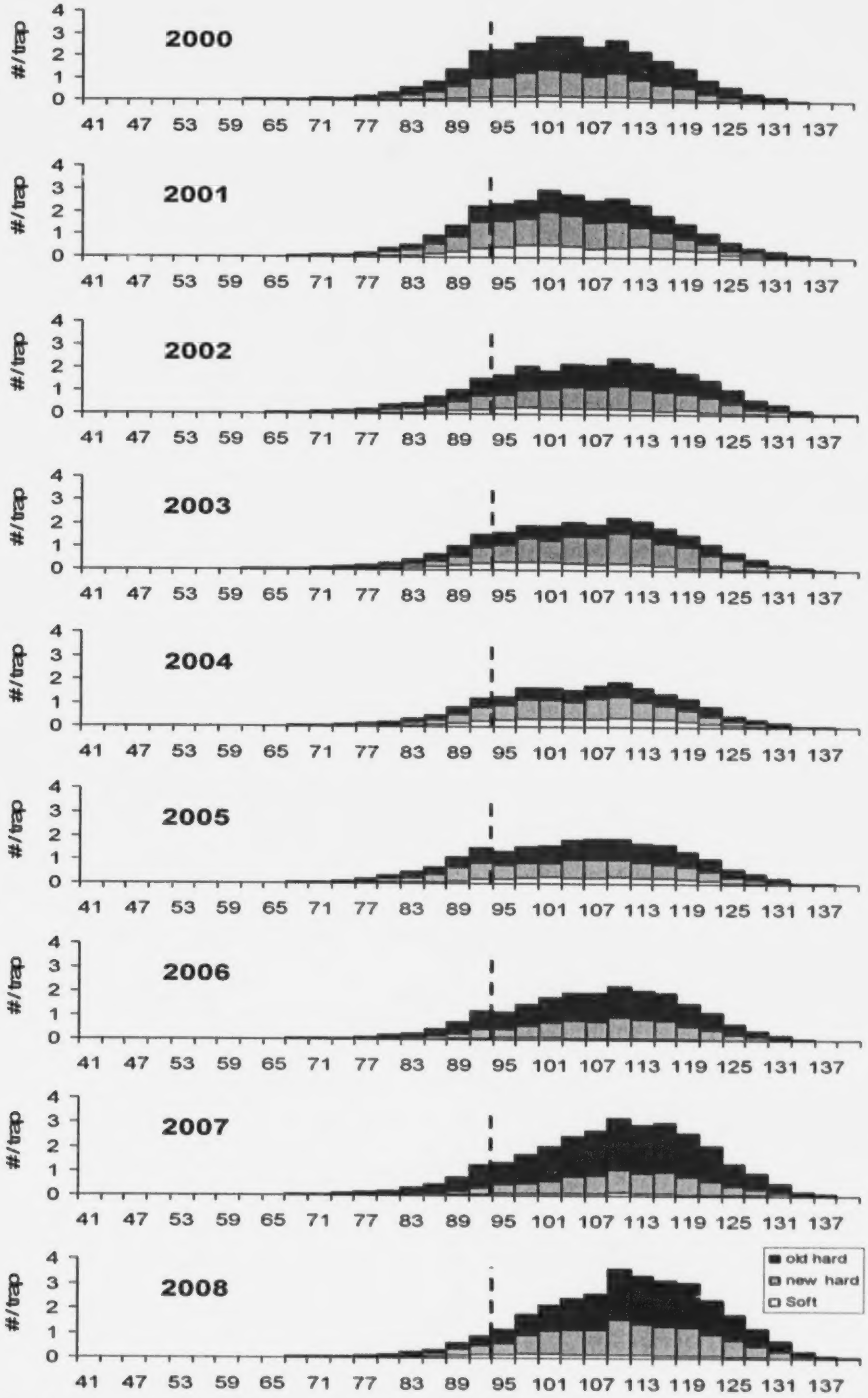


Figure 64. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3K offshore. The vertical dashed line indicates the minimum legal size.

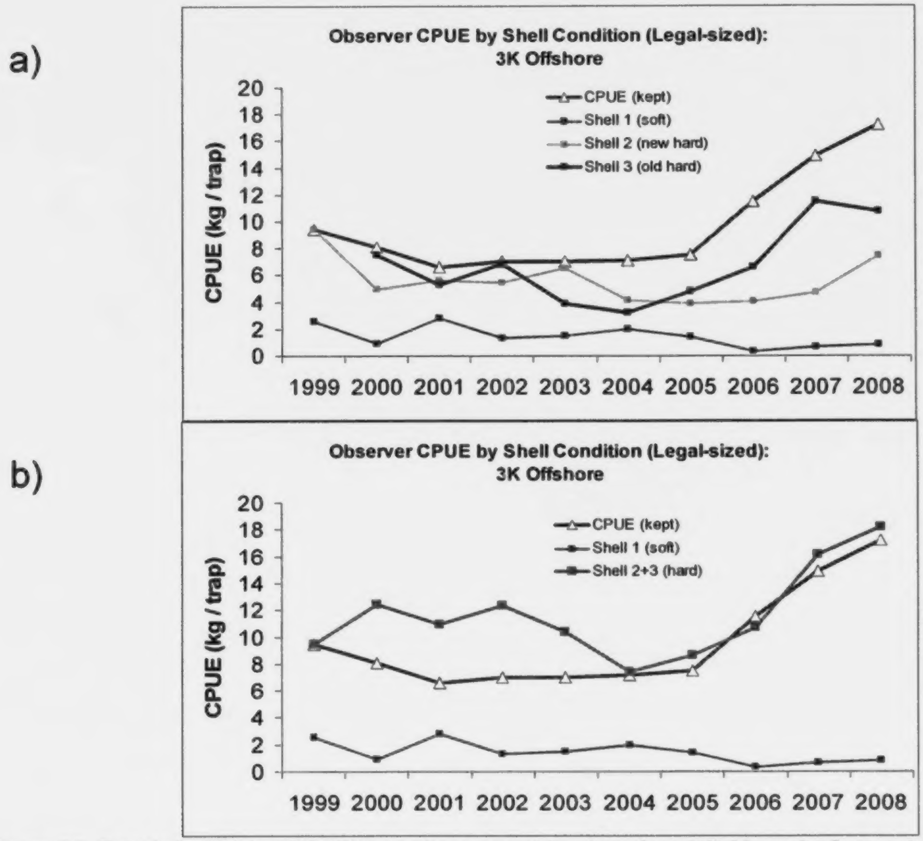


Figure 65. Trends in Division 3K offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

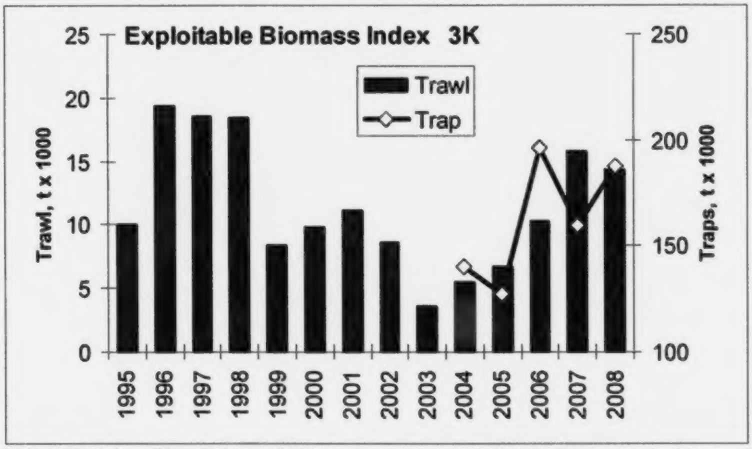


Figure 66. Trends in the Division 3K offshore fall trawl survey exploitable biomass index and the post-season survey biomass index.

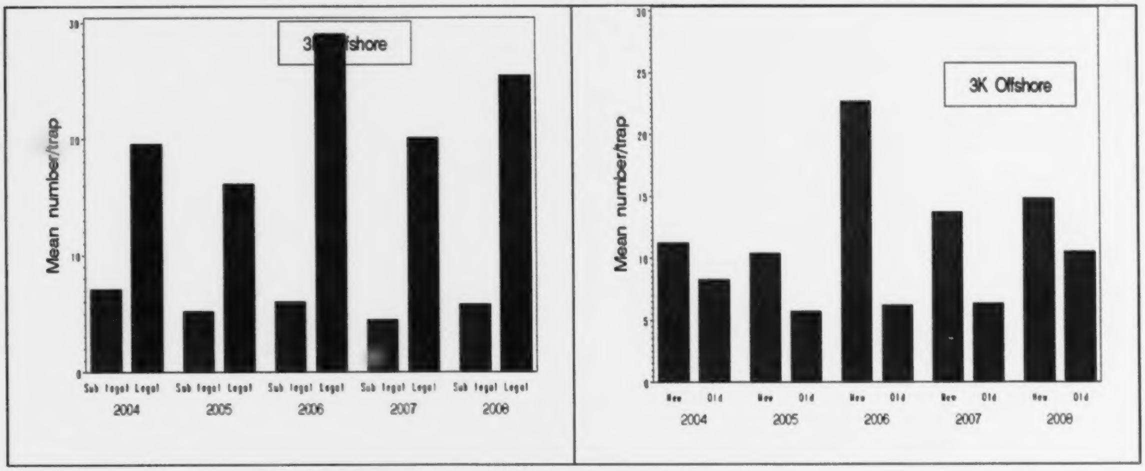


Figure 67. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 3K offshore industry-DFO collaborative post-season trap survey.

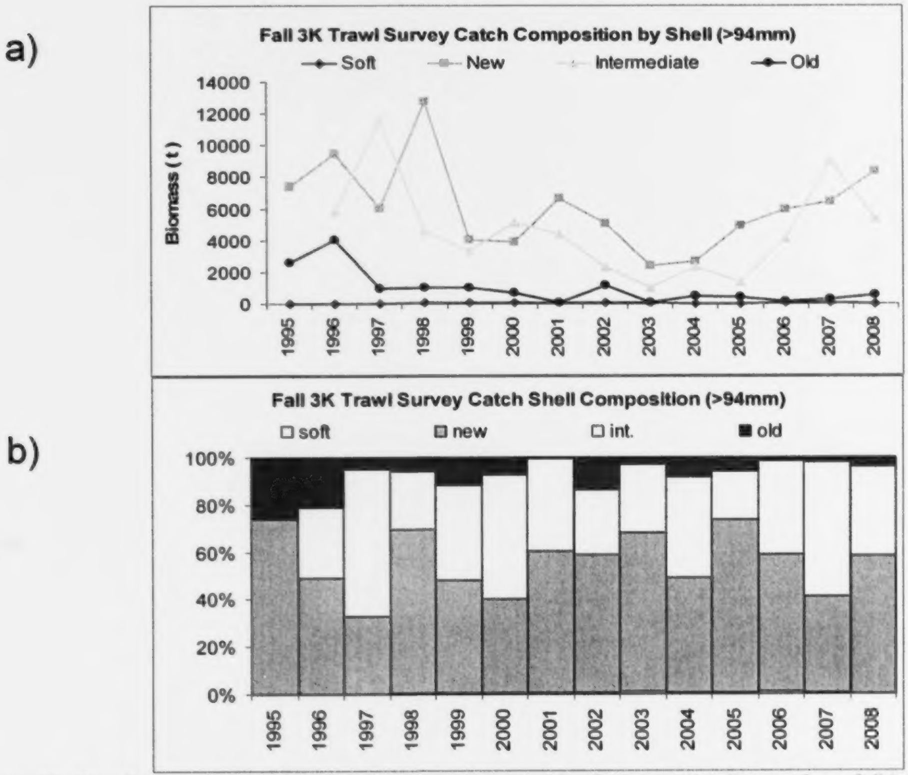


Figure 68. Trends, by shell condition, in legal-sized males for Division 3K offshore from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

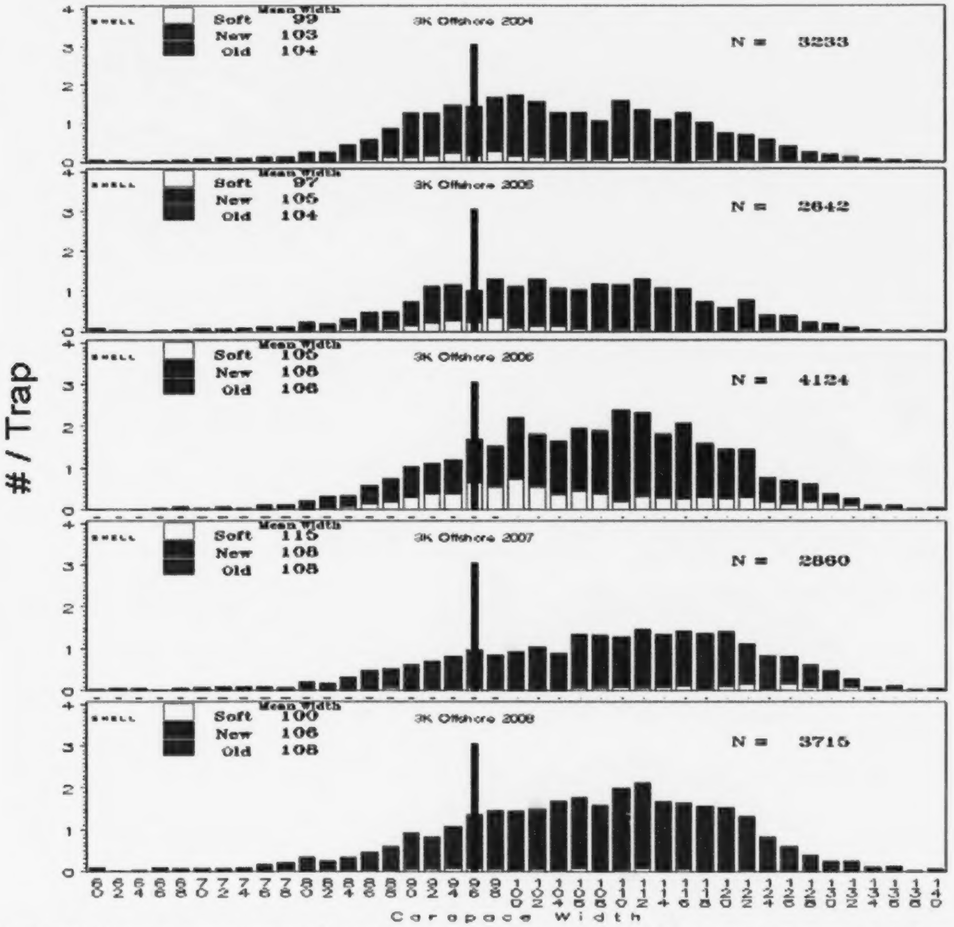


Figure 69. Trends in male carapace width distributions from common stations in the Division 3K offshore industry-DFO collaborative post-season trap survey. The vertical solid line indicates the minimum legal size.

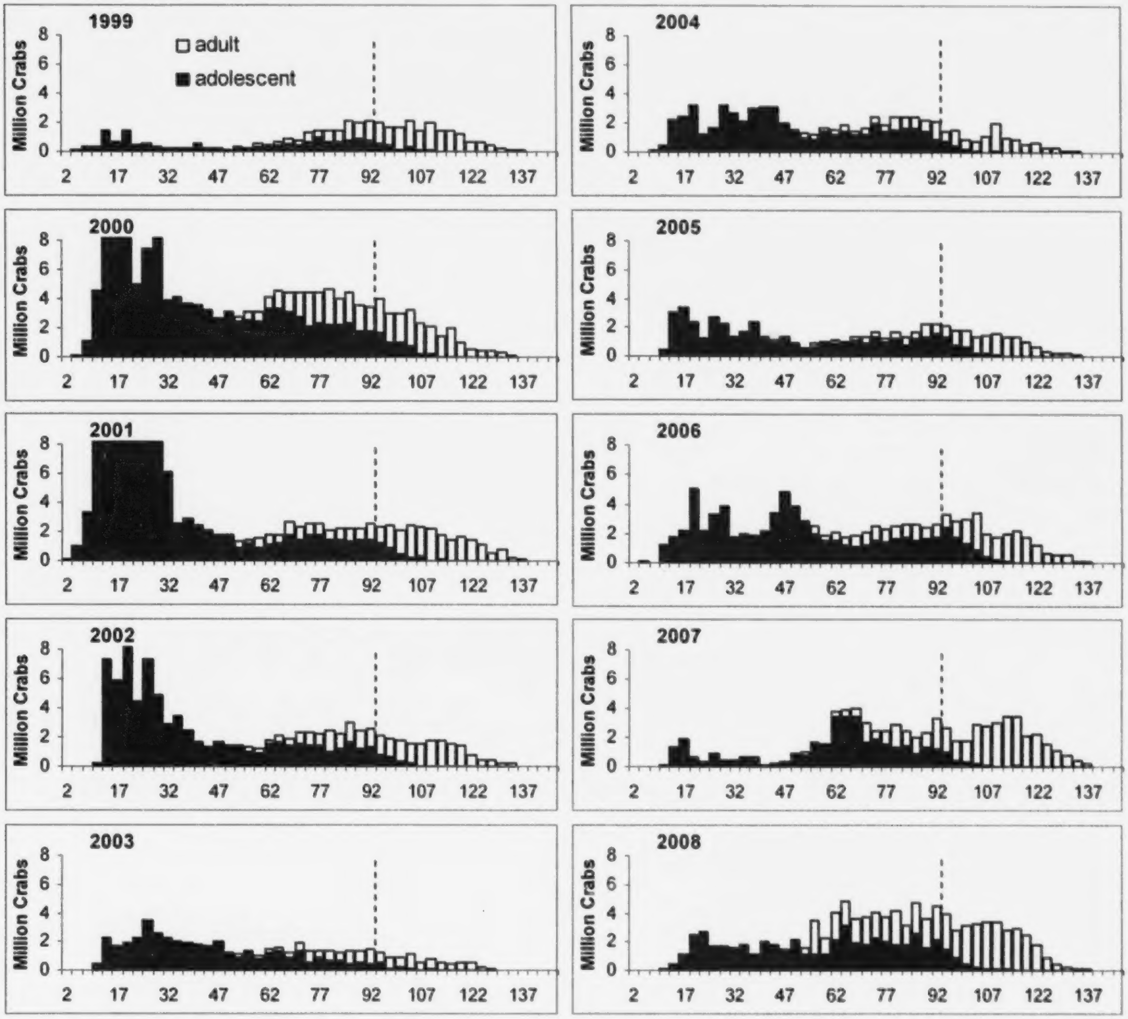


Figure 70. Distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

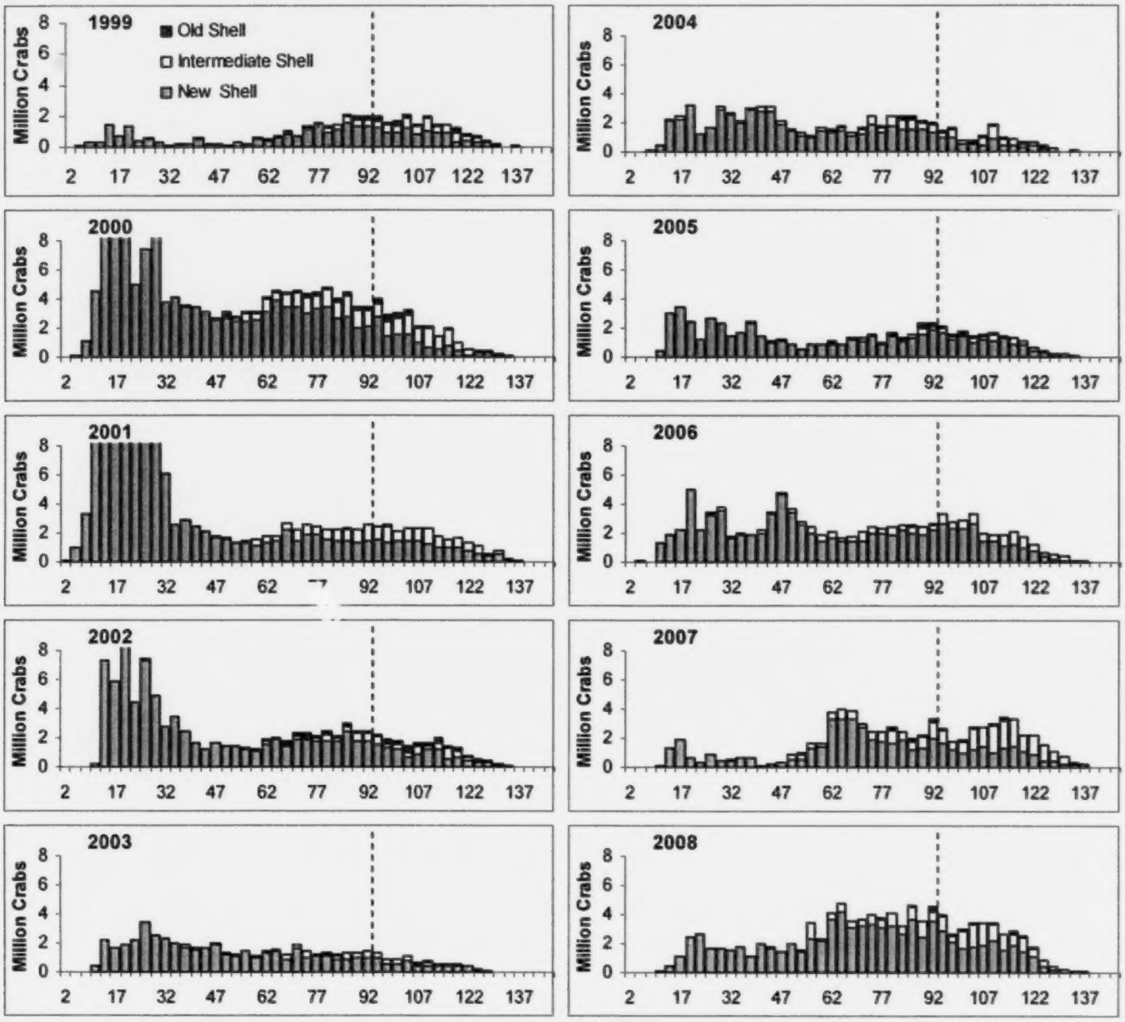


Figure 71. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 3K. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

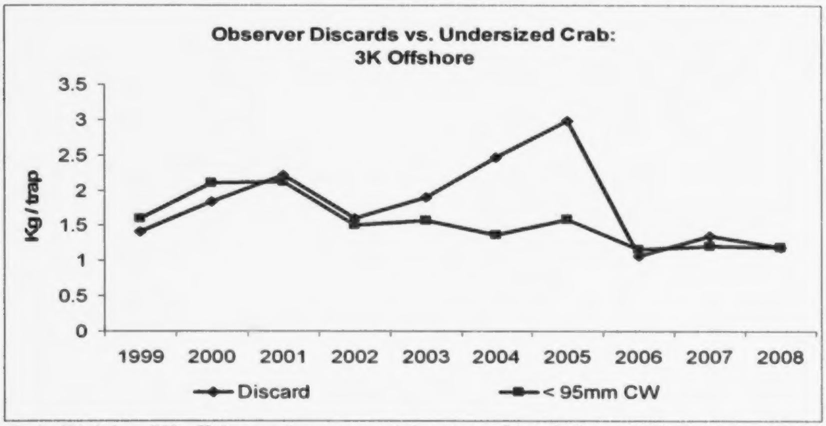


Figure 72. Trends in Division 3K offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

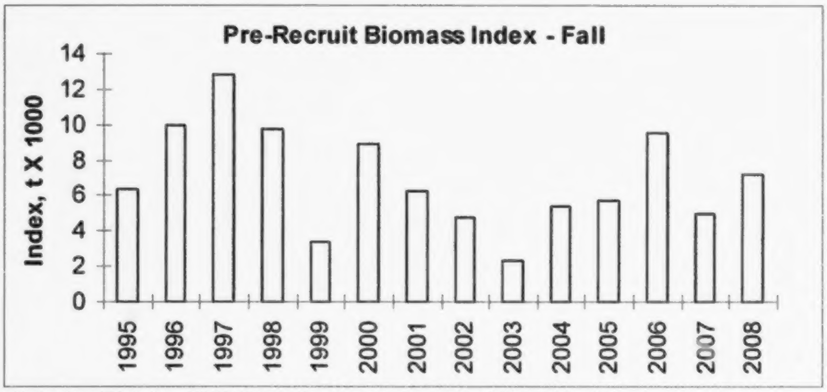


Figure 73. Trends in the Division 3K fall trawl survey pre-recruit biomass index.

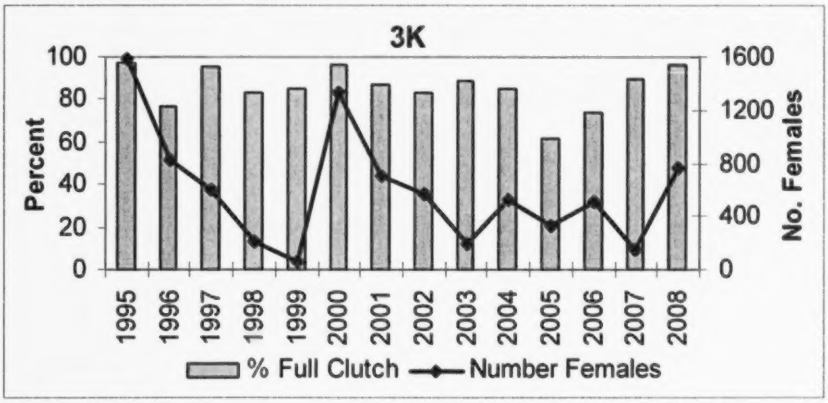


Figure 74. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3K from fall multi-species surveys.

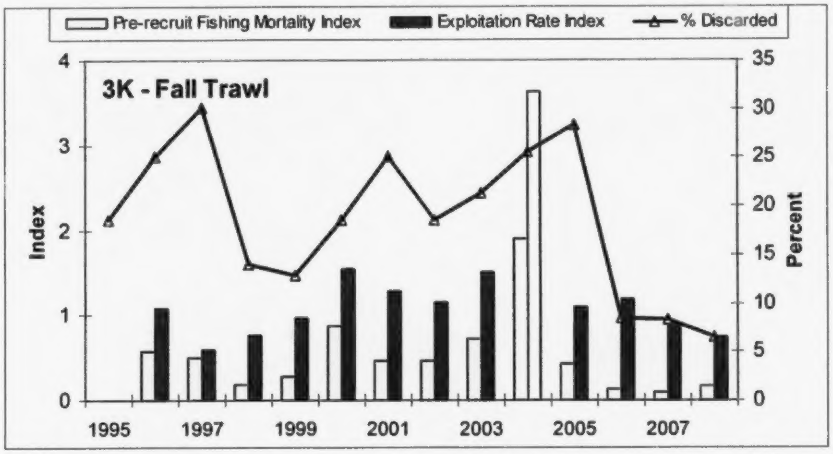


Figure 75. Trends in Division 3K offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (anomalously high 2004 values are attributable to low catch rates in 2003 trawl survey).

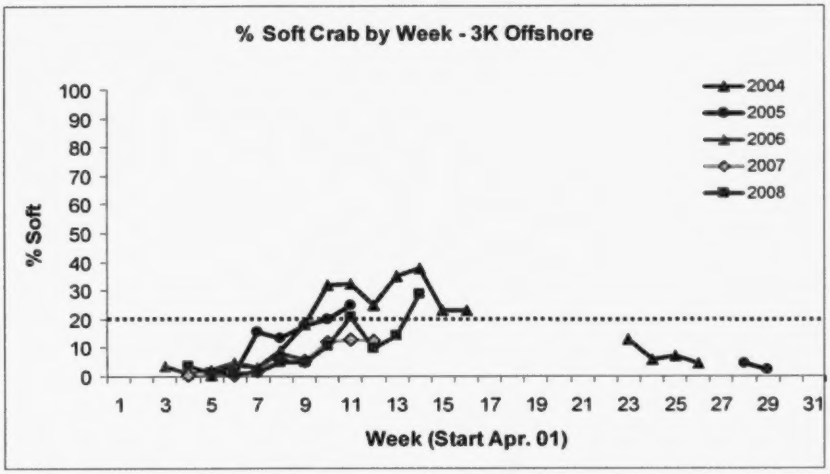


Figure 76. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3K offshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

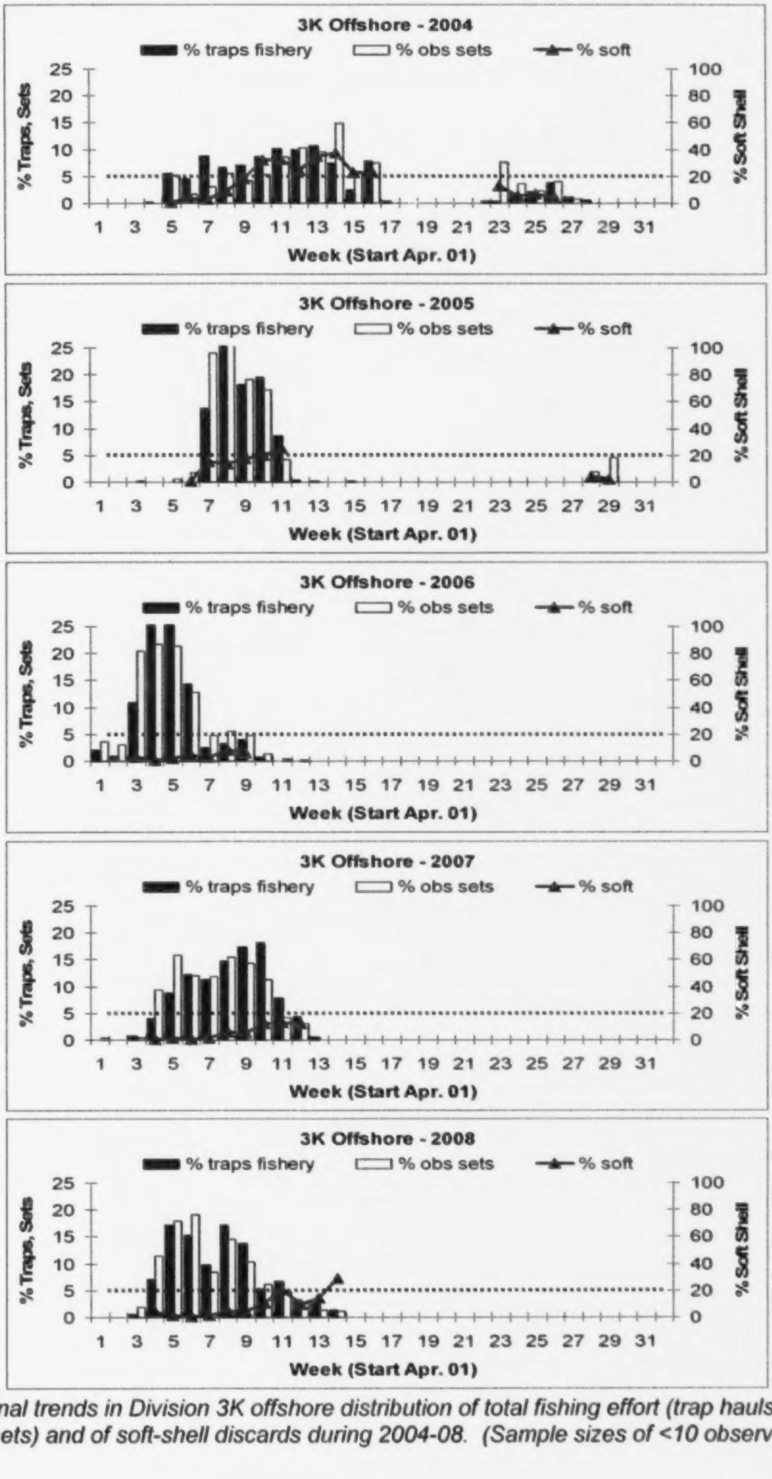


Figure 77. Seasonal trends in Division 3K offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2004-08. (Sample sizes of <10 observed sets/week removed)

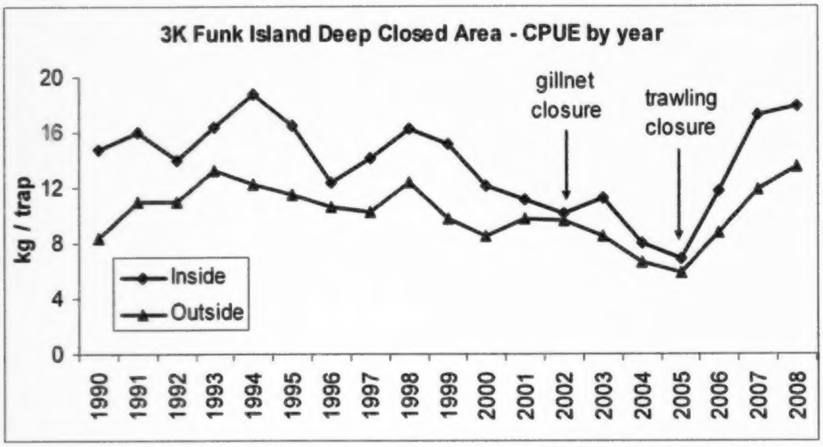


Figure 78. Division 3K offshore commercial CPUE; inside vs. outside the Funk Island Deep closed area.

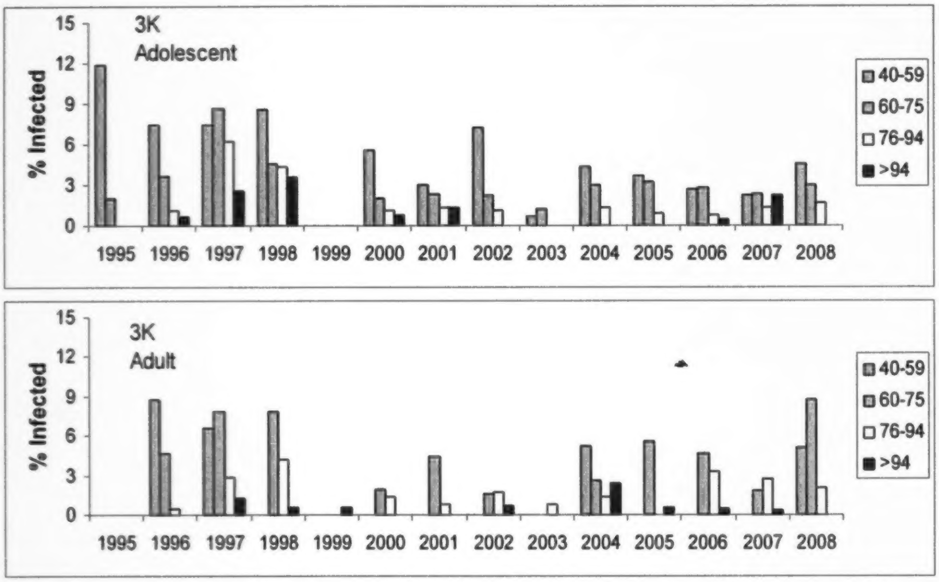


Figure 79. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 3K fall trawl surveys.

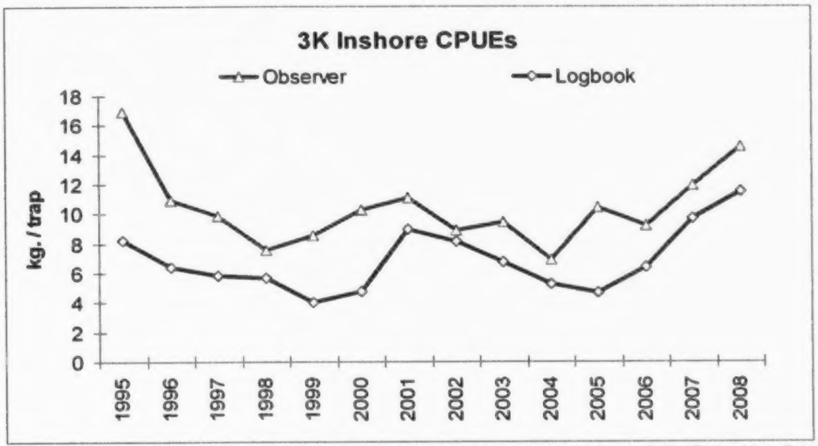


Figure 80. Trends in commercial logbook-based CPUE and observer-based CPUE in the Division 3K inshore fishery.

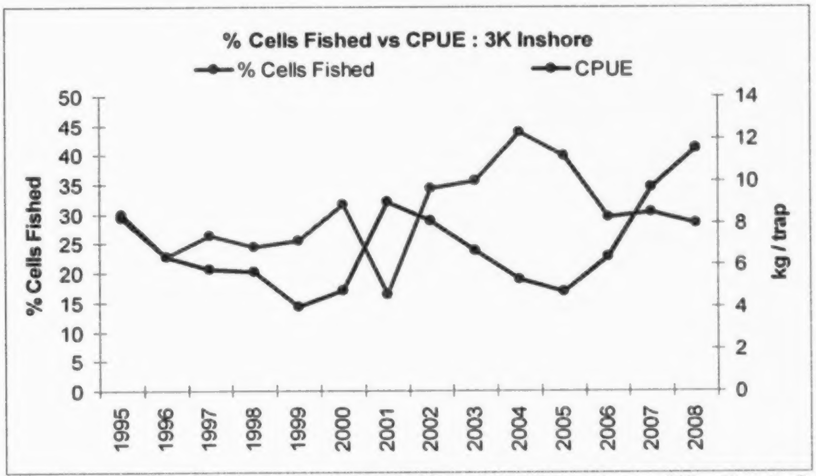


Figure 81. Trends in Division 3K inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

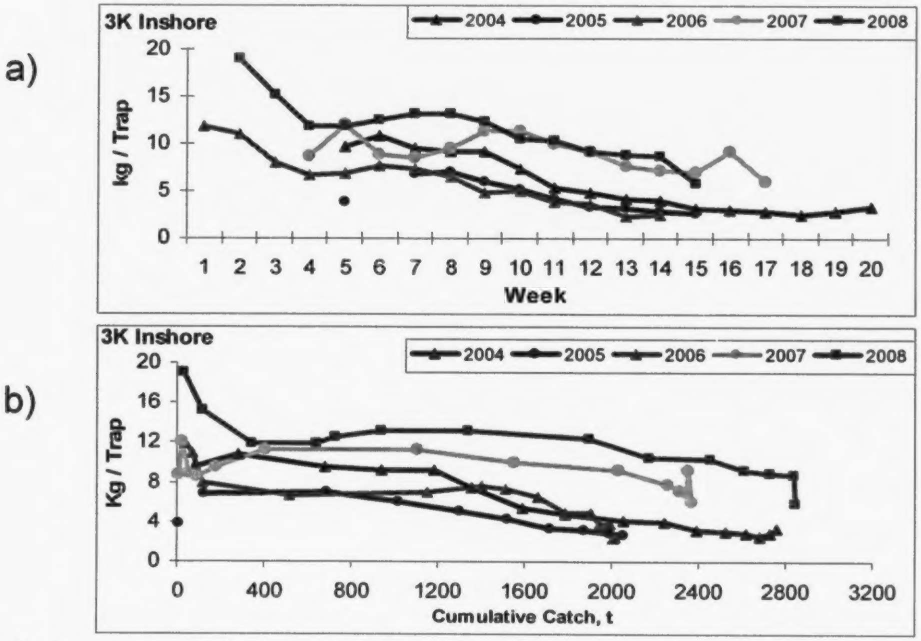


Figure 82. Seasonal trends in logbook-based CPUE for Division 3K inshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

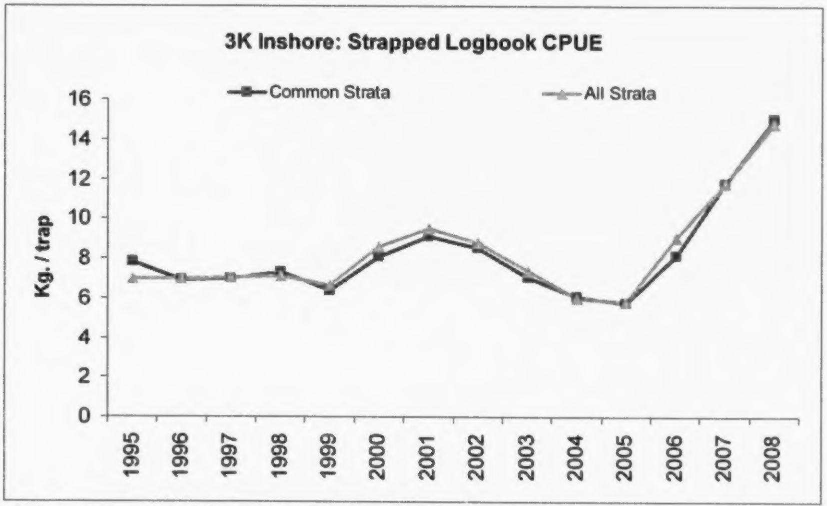


Figure 83. Trends in mean catch rates in the Division 3K inshore fishery based on spatially-expanded logbook STRAP analysis.

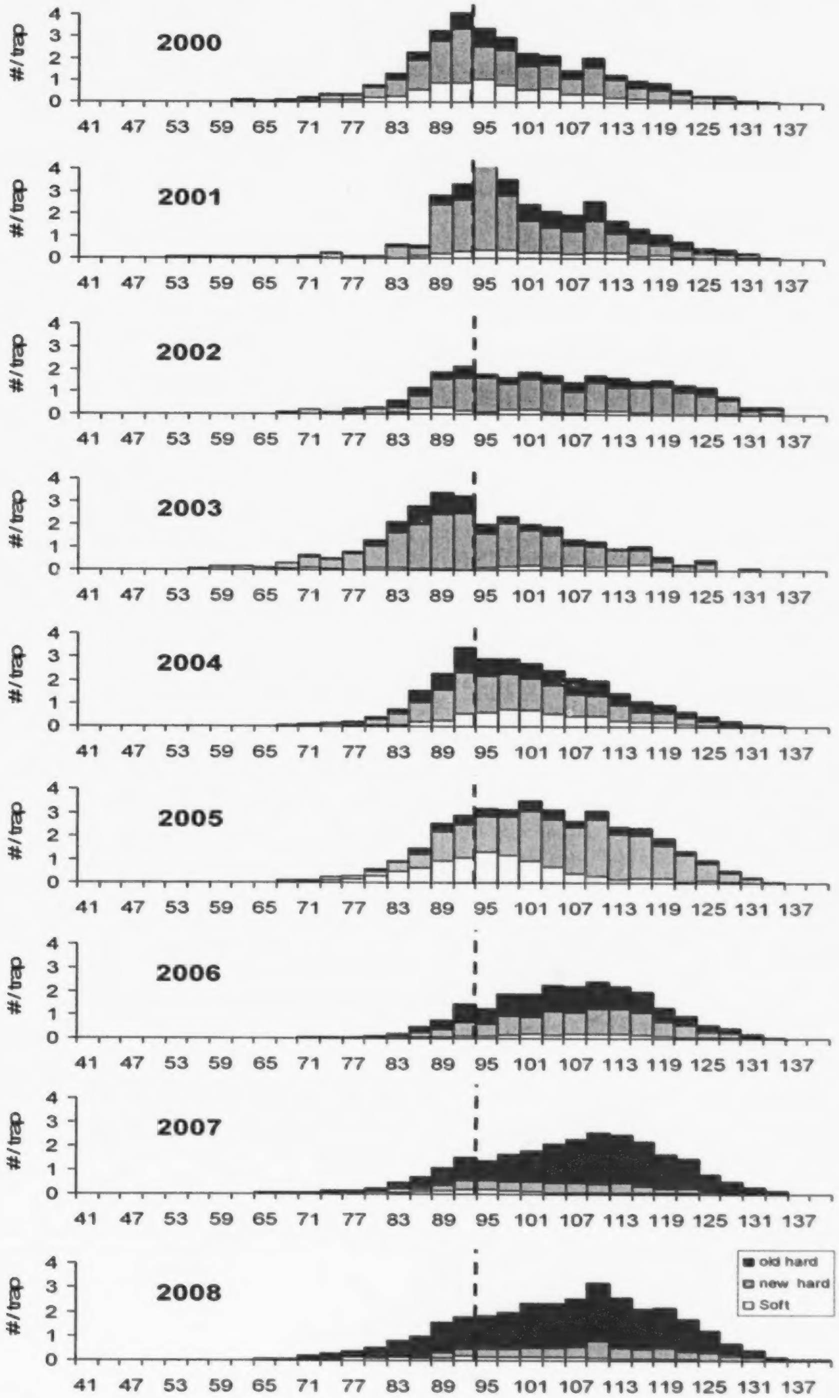


Figure 84. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3K inshore. The vertical dashed line indicates the minimum legal size.

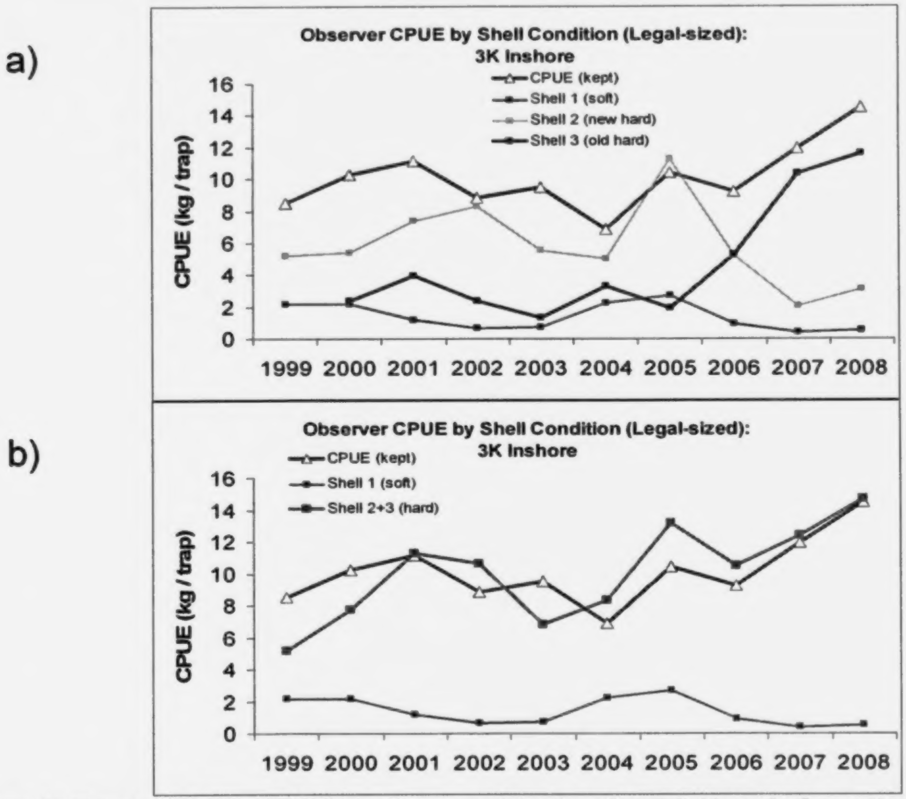


Figure 85. Trends in Division 3K inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

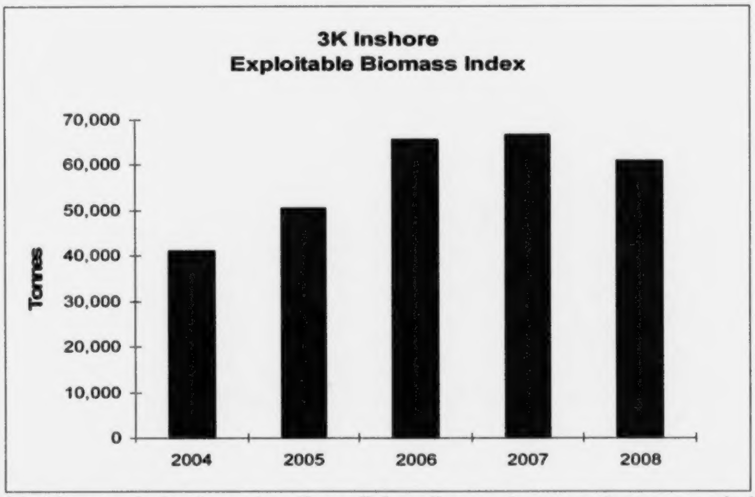


Figure 86. Exploitable biomass index based on the collaborative post-season trap survey in inshore Division 3K.

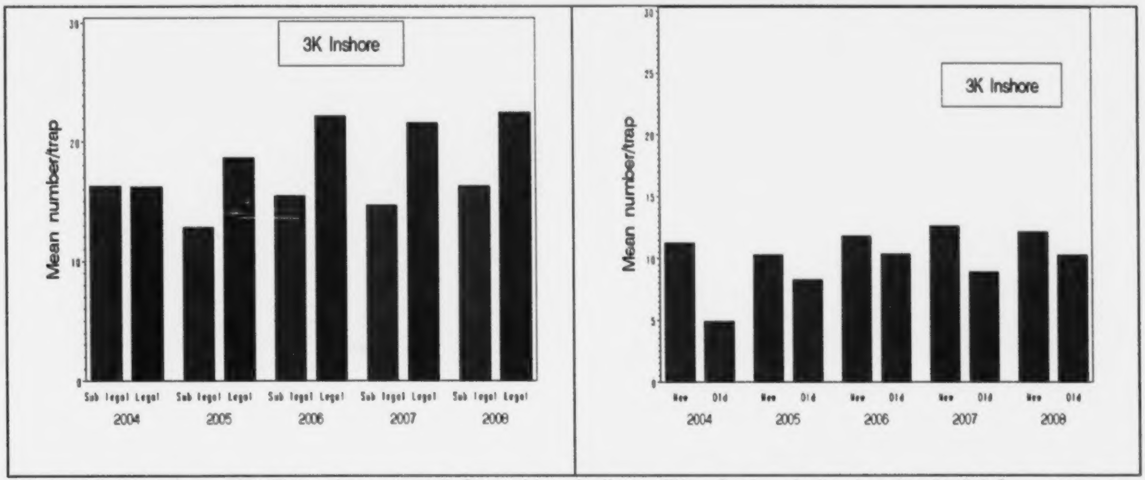


Figure 87. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 3K inshore industry-DFO collaborative post-season trap survey.

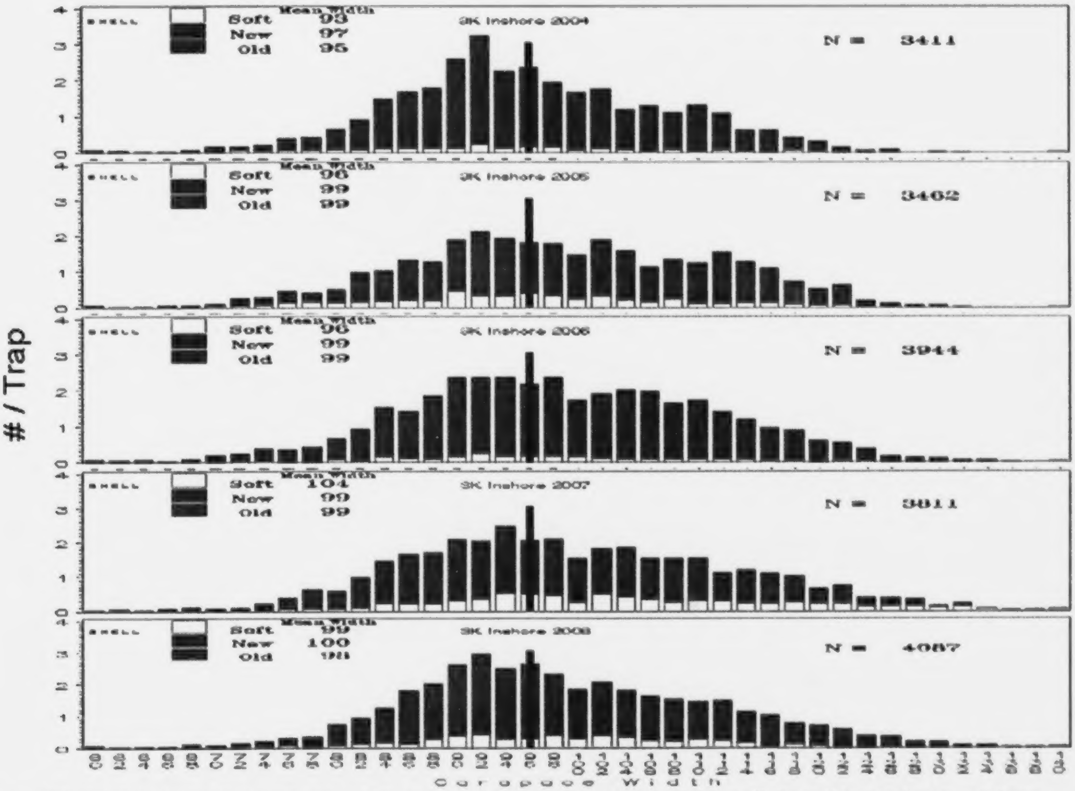


Figure 88. Trends in male carapace width distributions from industry-DFO collaborative post-season trap surveys (all stations) for Division 3K inshore.

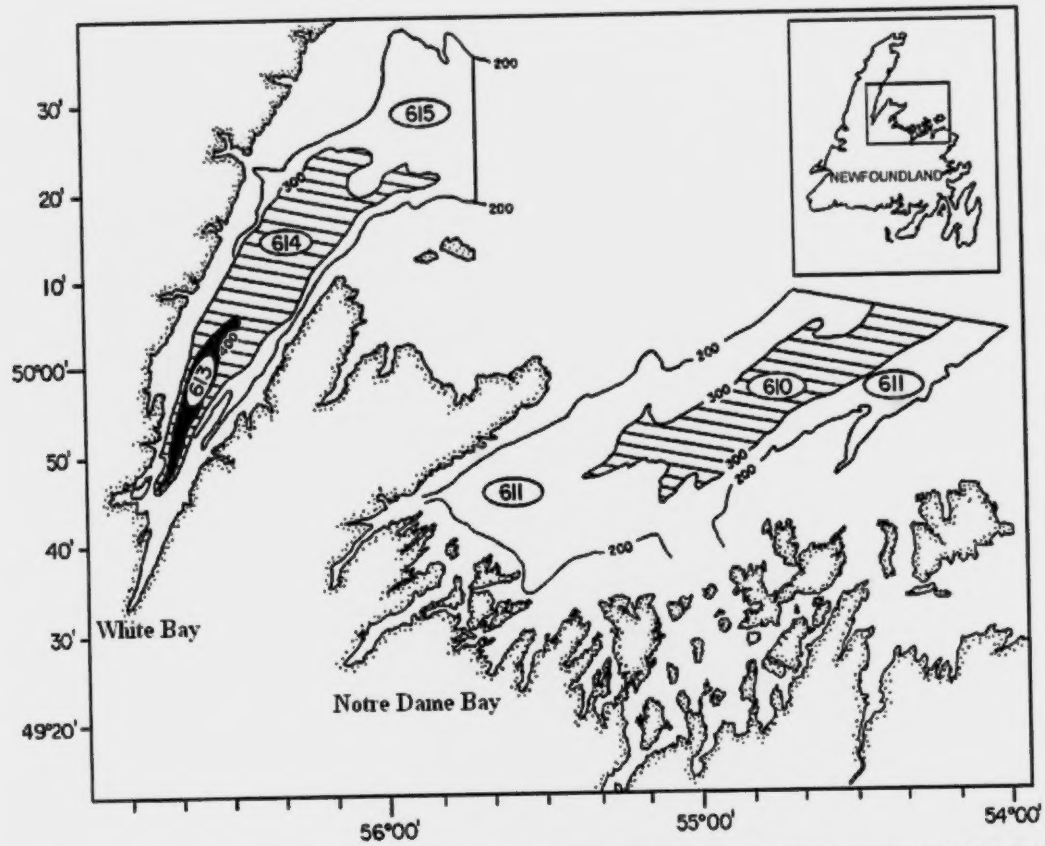

30'
20'
10'
50°00'
50'
40'
30'
49°20'
56°00'
55°00'
54°00'
615
614
613
610
611
611
200
300
100
NEWFOUNDLAND
White Bay
Notre Dame Bay

Figure 89. Location map showing inshore Division 3K strata sampled during fall trap surveys in White Bay and Notre Dame Bay.

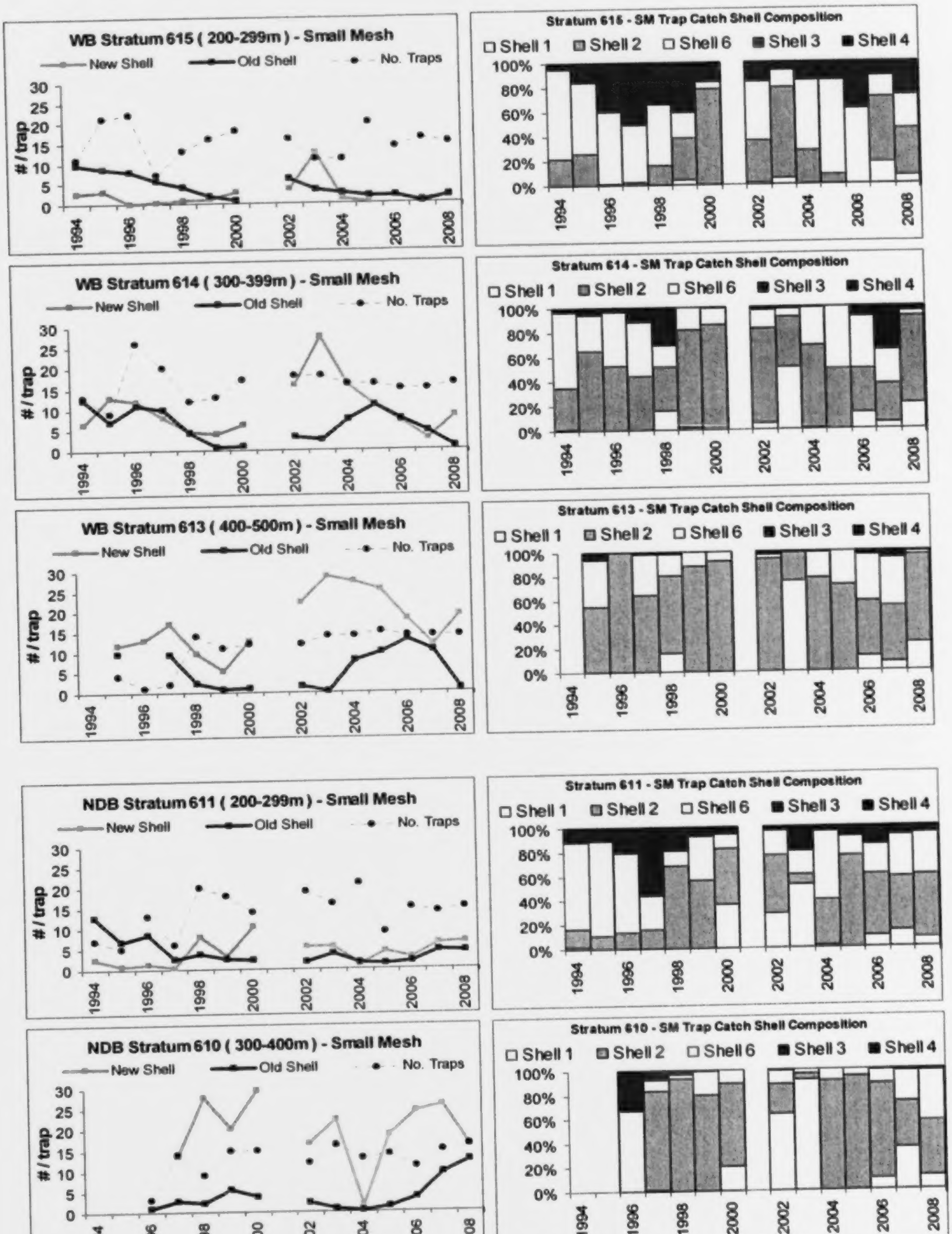


Figure 90. Trends from small-mesh traps in shell condition of catches by stratum from inshore Division 3K trap surveys in White Bay (top panels) and Notre Dame Bay (bottom panels), 1994-2008; no survey was conducted in 2001.

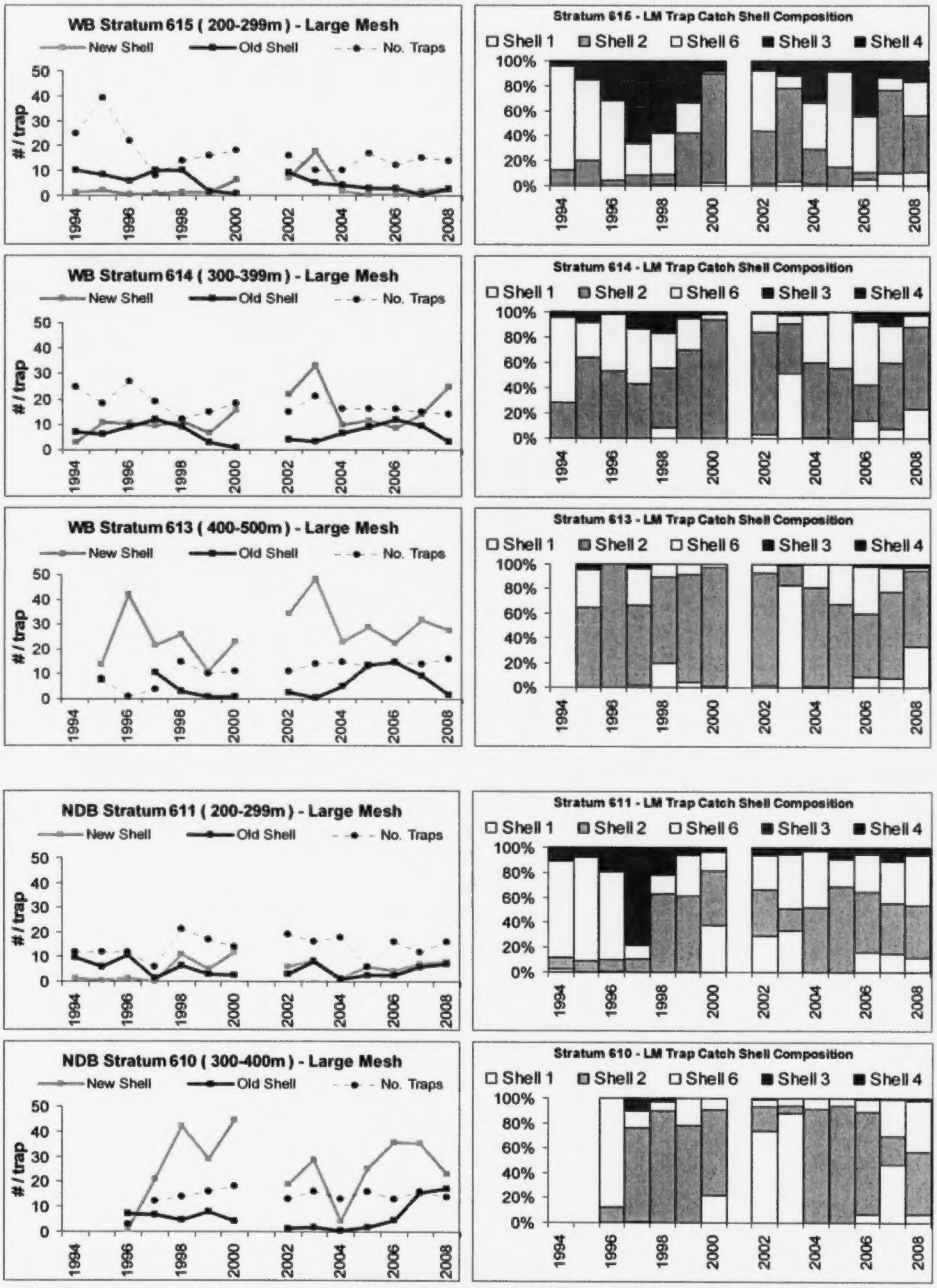


Figure 90b. Trends from large-mesh traps in shell condition of catches by stratum from inshore Division 3K trap surveys in White Bay (top panels) and Notre Dame Bay (bottom panels), 1994-2008; no survey was conducted in 2001.

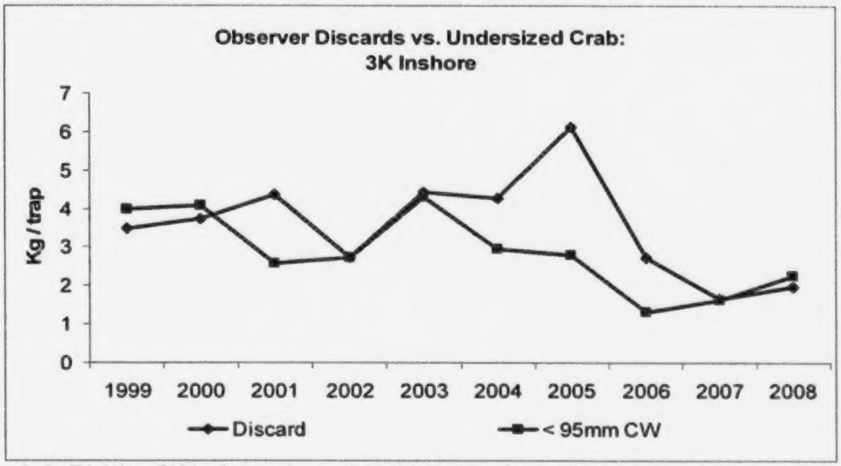


Figure 91. Trends in Division 3K inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

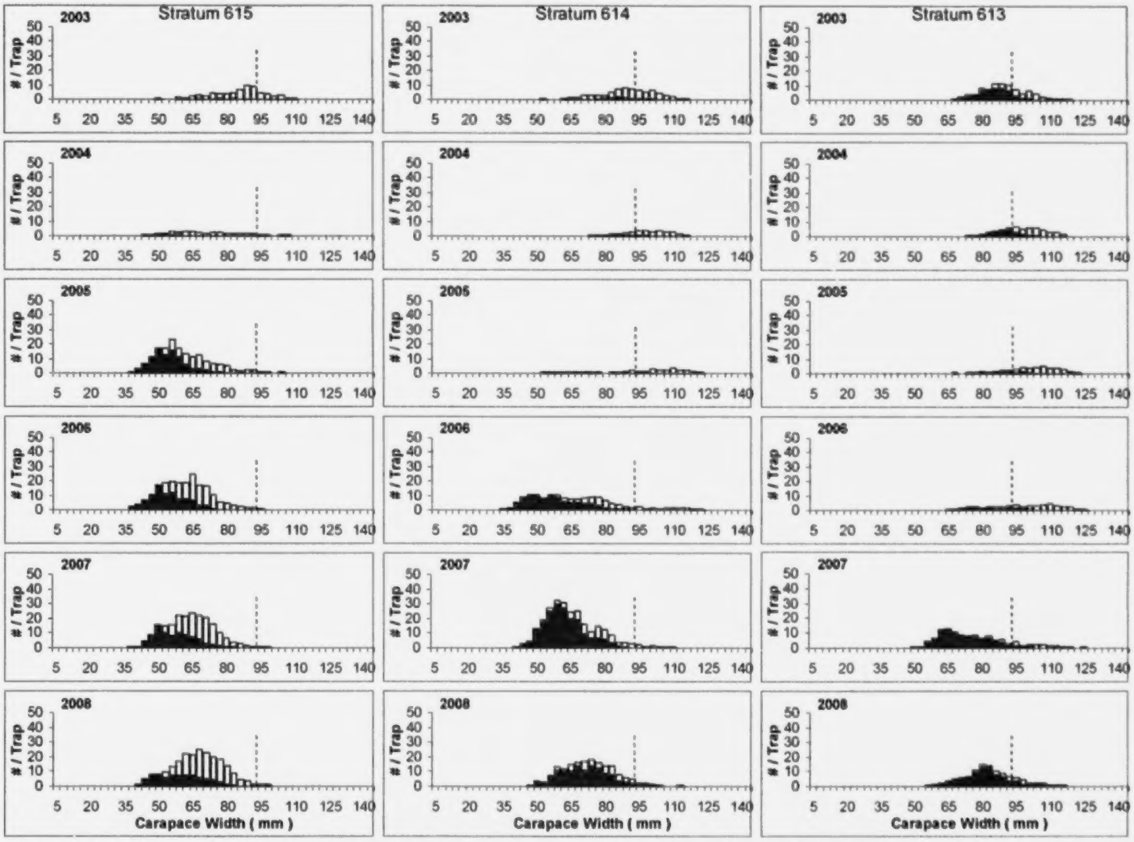


Figure 92. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within White Bay; Stratum 615 (200–299m), Stratum 614 (300-399 m) and Stratum 613 (400-500 m).

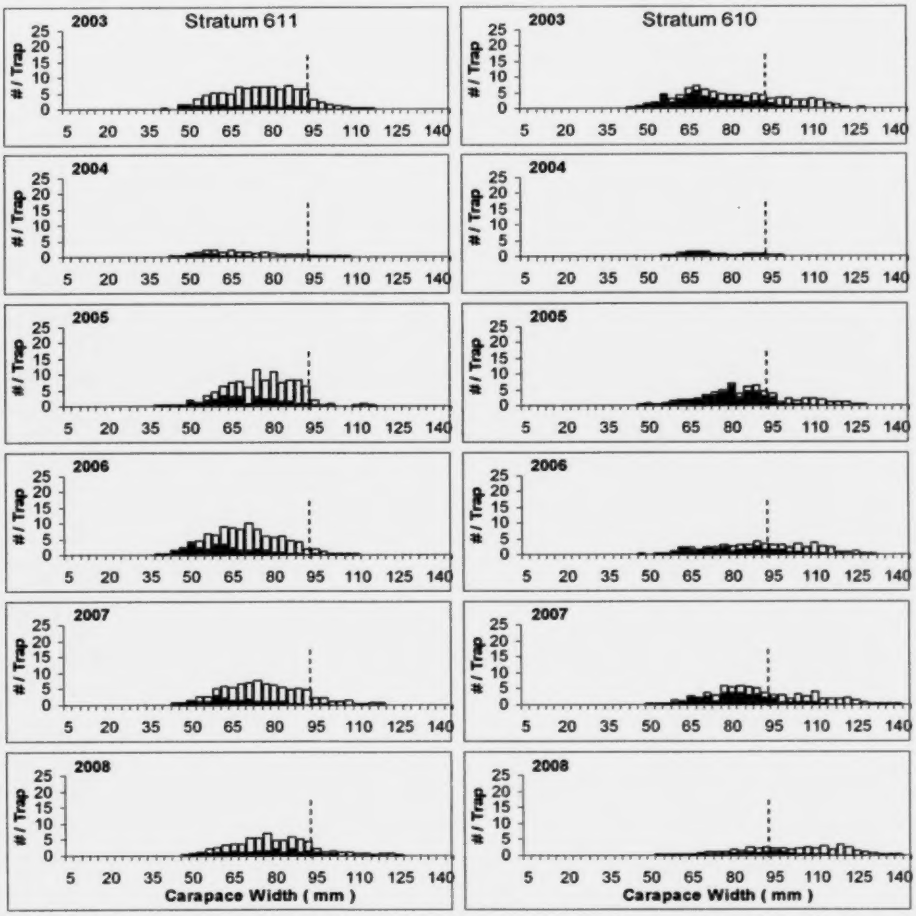


Figure 93. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within Notre Dame Bay; Stratum 611 (200–299 m) and Stratum 610 (300-399 m).

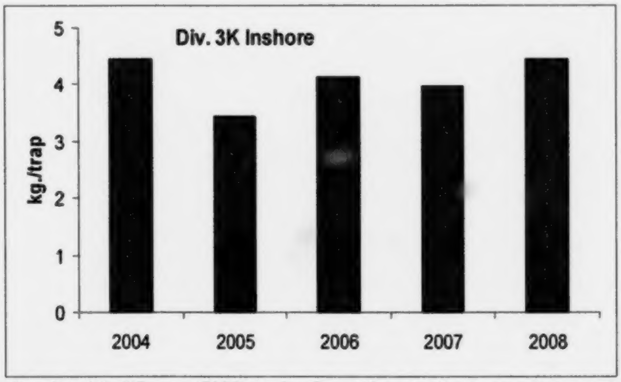


Fig. 94. Catch rates of undersized (<95 mm CW) crabs from the post-season trap survey in inshore Division 3K.

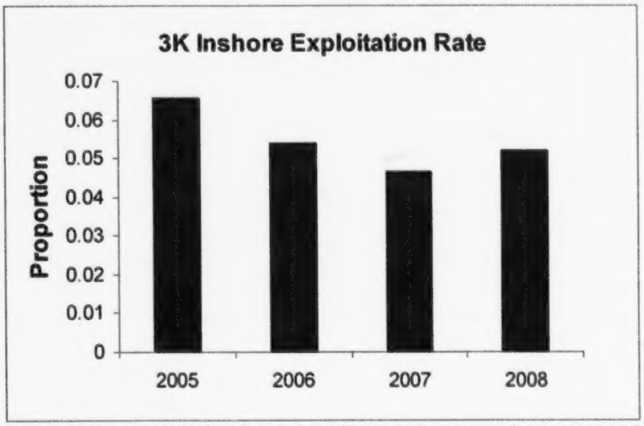


Figure 95. Trends in the exploitation rate index based on the post-season trap survey in Division 3K.

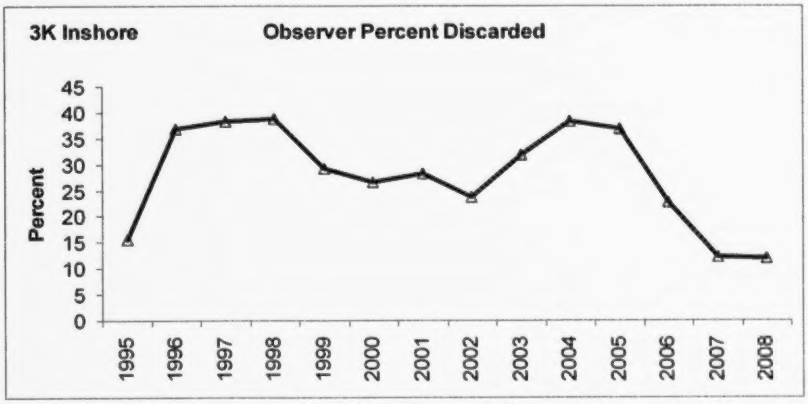


Figure 96. Trends in Division 3K inshore percentage of the catch discarded in the fishery.

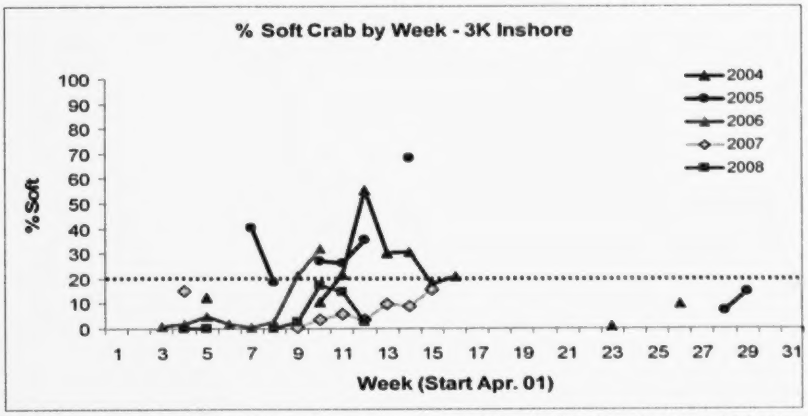


Figure 97. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3K inshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

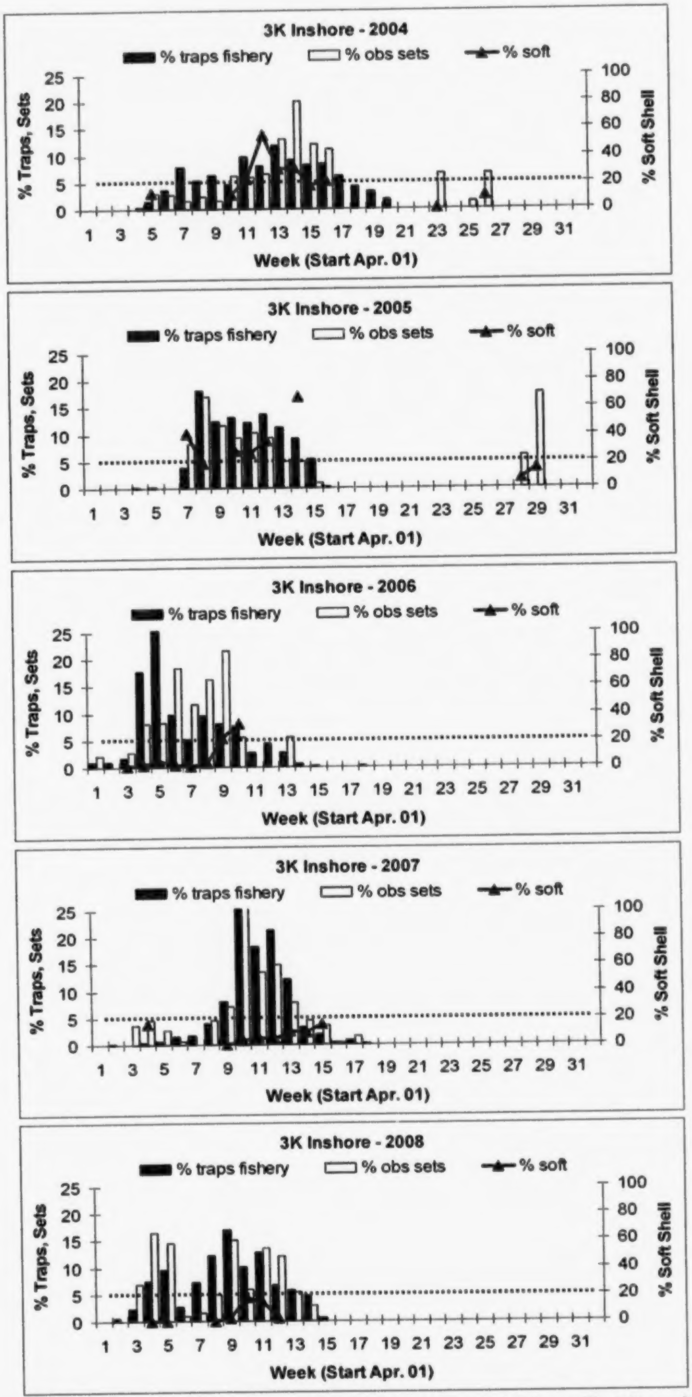


Figure 98. Seasonal trends in Division 3K inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed)

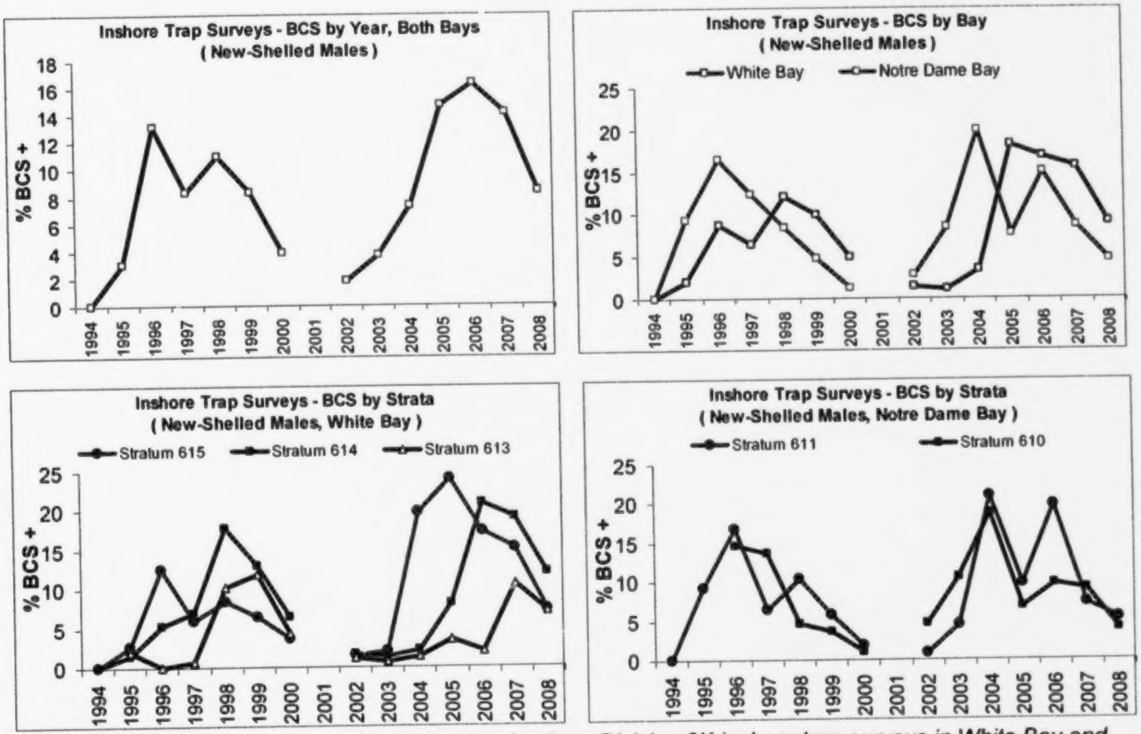


Figure 99. Prevalence of BCD in new-shelled males from Division 3K inshore trap surveys in White Bay and Notre Dame Bay for both bays combined (top left panel), by bay (top right panel), White Bay by stratum (bottom left panel) and Notre Dame Bay by stratum (bottom right panel).

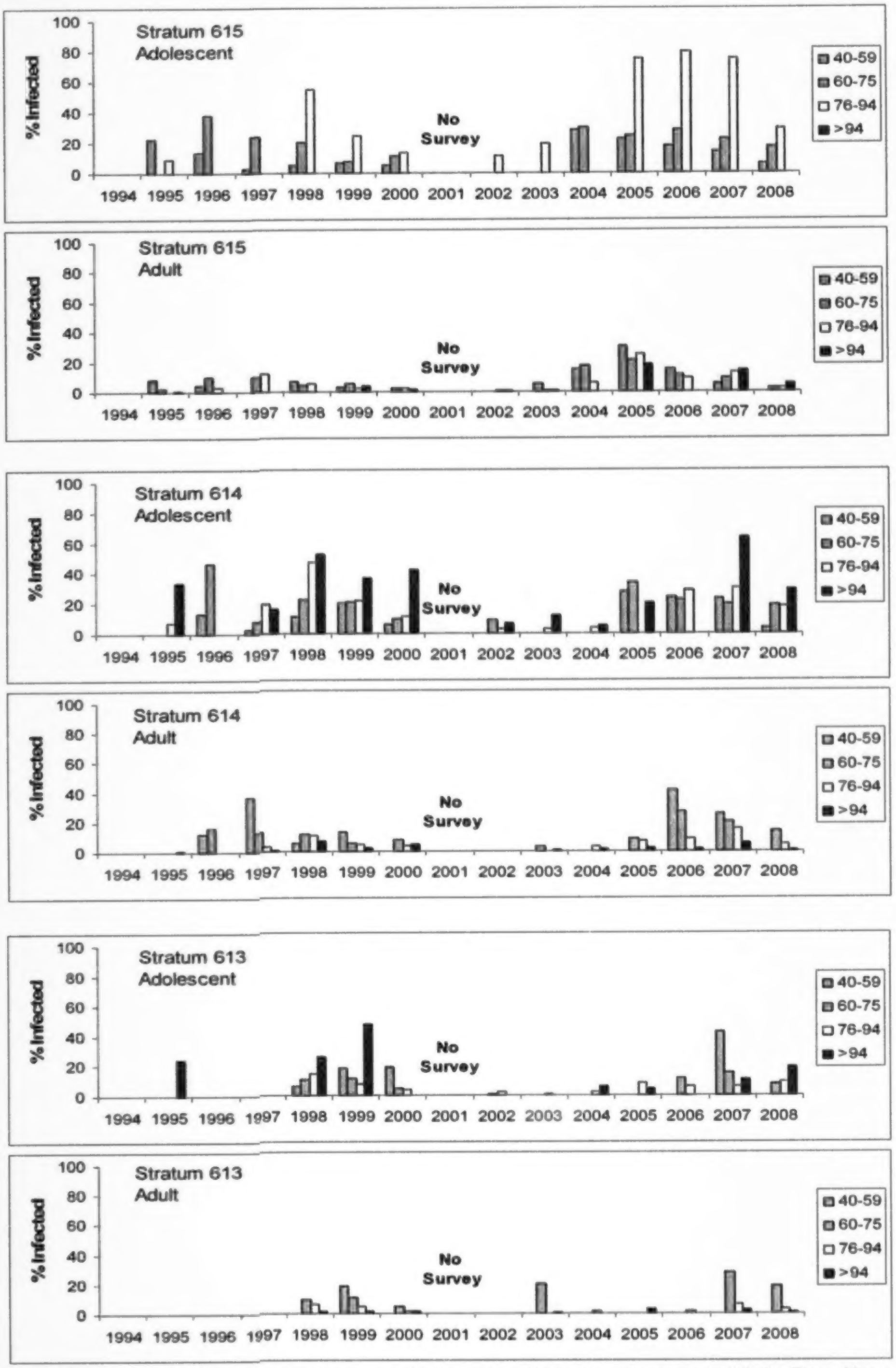


Figure 100. Incidence of BCD by stratum, year, and size group from trap surveys in White Bay; New-shelled males in adolescents (above) and adults (below).

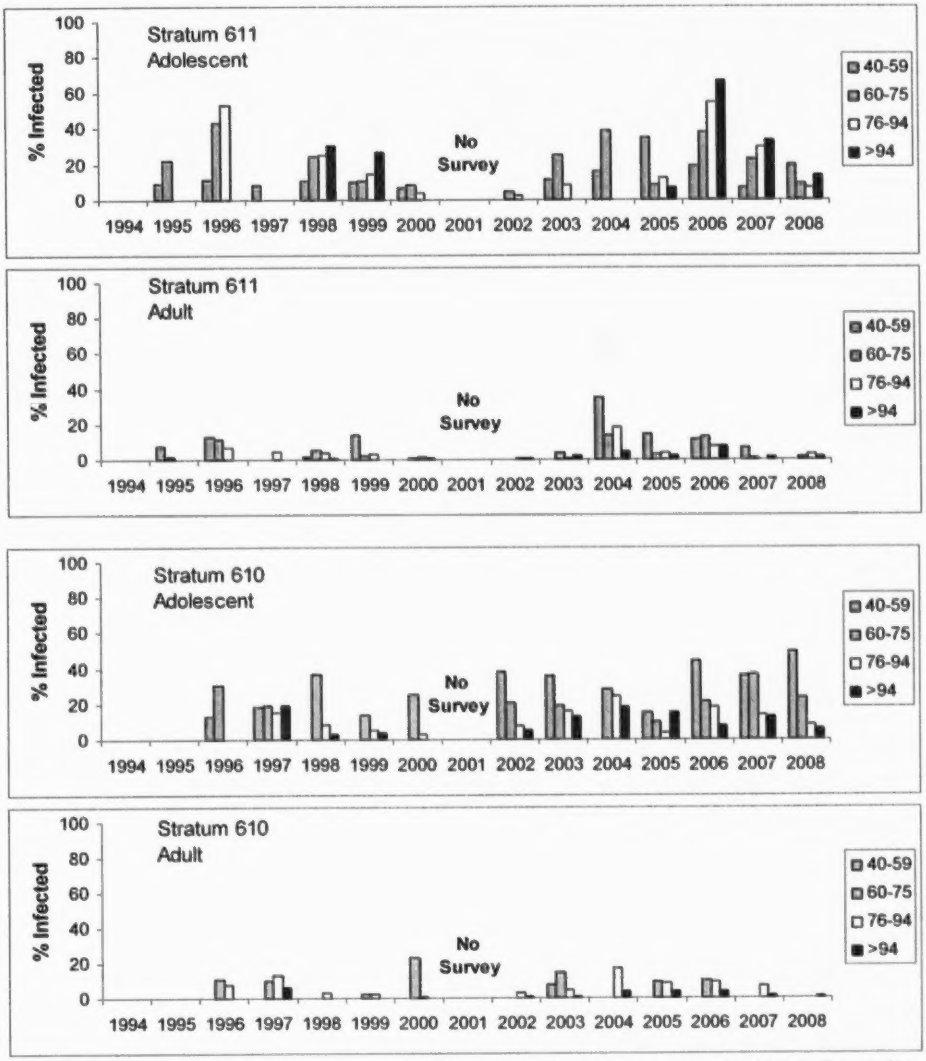


Figure 101. Incidence of BCD by stratum, year, and size group from trap surveys in Notre Dame Bay; New-shelled males in adolescents (above) and adults (below).

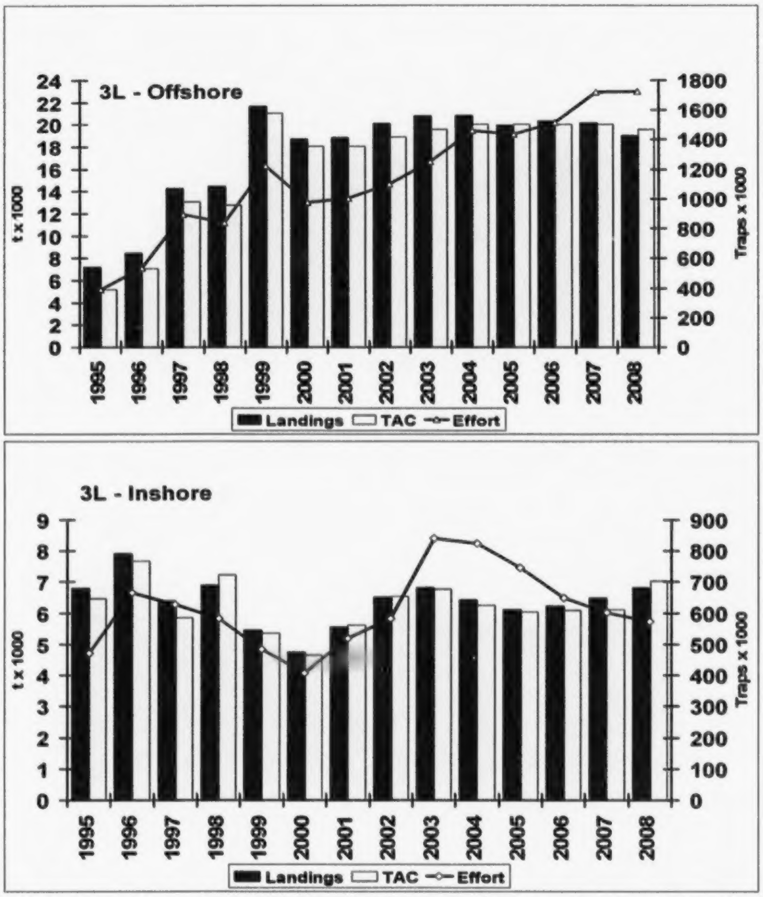


Figure 102. Trends in Division 3L landings, TAC, and fishing effort for the offshore (above) and inshore (below).

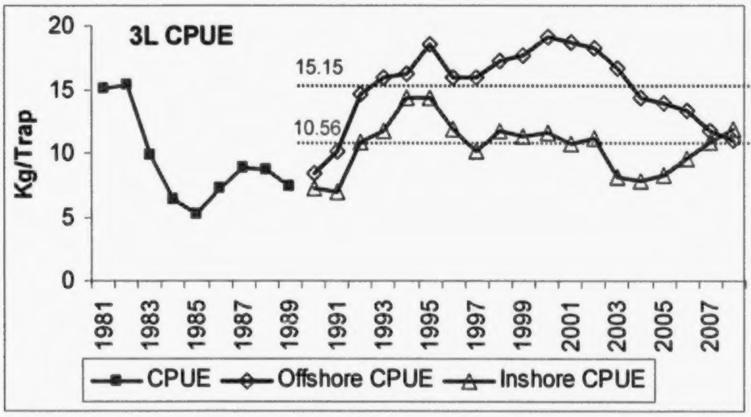


Figure 103. Trends in Division 3L offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

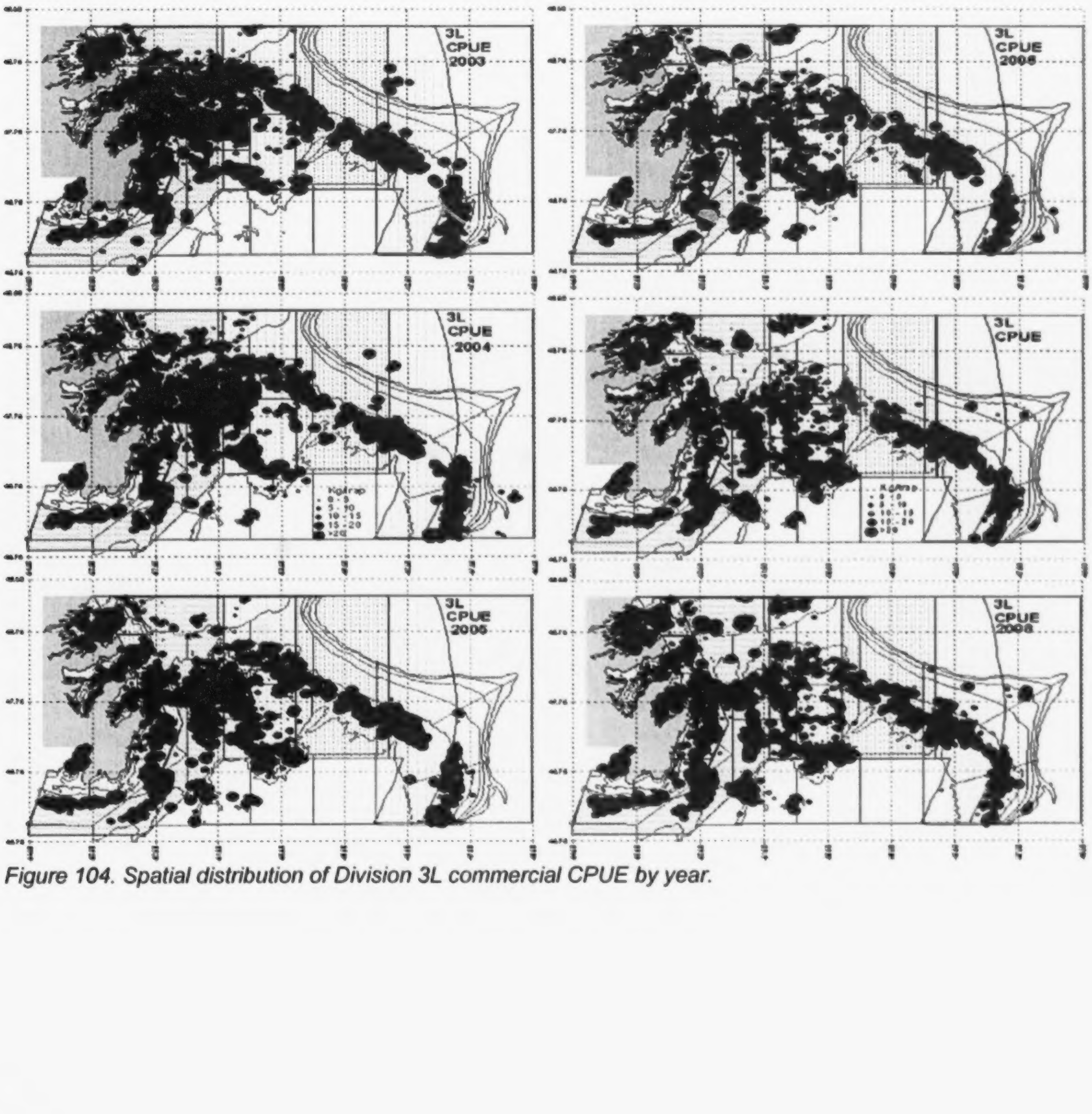

3L CPUE 2003
3L CPUE 2006
3L CPUE 2004
3L CPUE
Kg/trap
0 - 5
5 - 10
10 - 15
15 - 20
>20
3L CPUE 2005
3L CPUE 2008

Figure 104. Spatial distribution of Division 3L commercial CPUE by year.

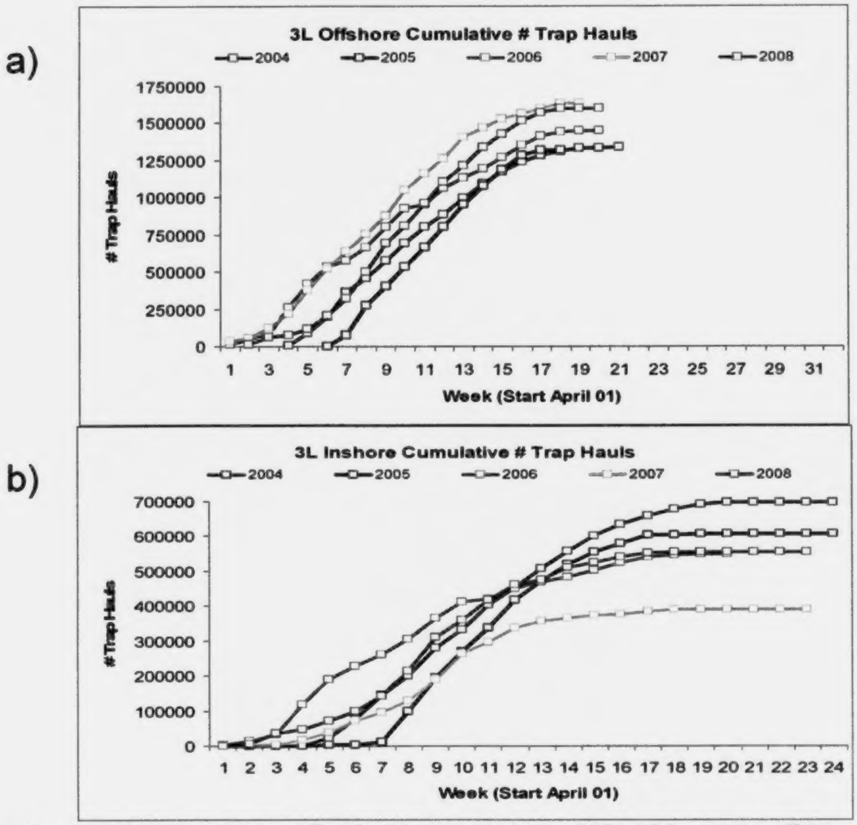


Figure 105. Seasonal trends in fishing effort for Division 3L during 2004-08 for (a) the offshore and (b) the inshore.

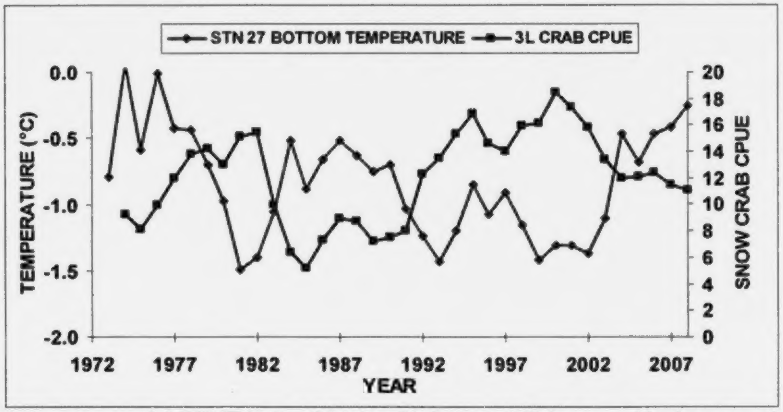


Figure 106. Trends in commercial CPUE in the Division 3L fishery (offshore and inshore combined) vs. bottom temperature at an eight year lag.

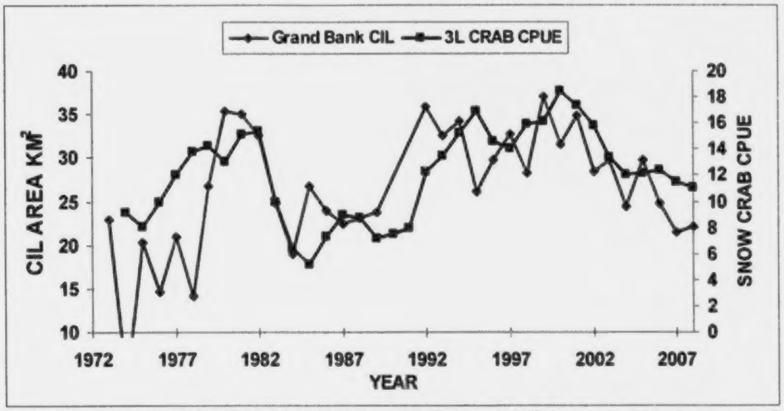


Figure 107. Trends in commercial CPUE in the Division 3L fishery (offshore and inshore combined) vs. spatial extent of the cold intermediate layer at an eight year lag.

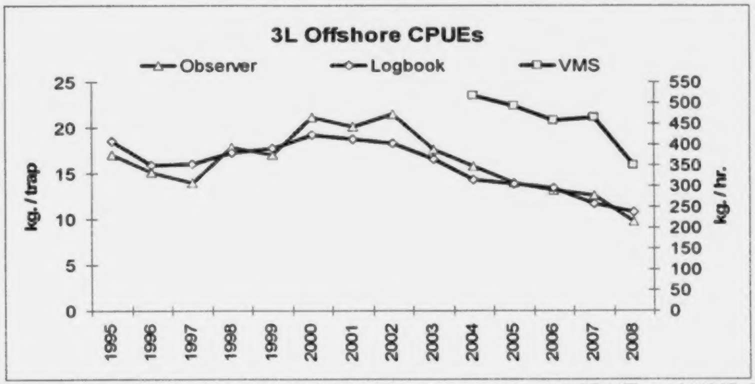


Figure 108. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3L offshore fishery.

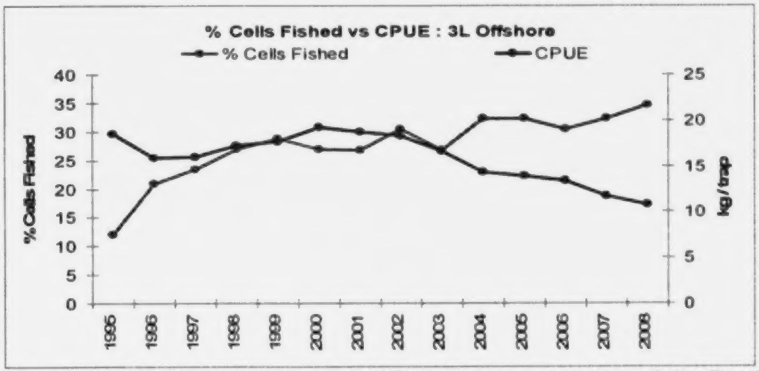


Figure 109. Trends in Division 3L offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

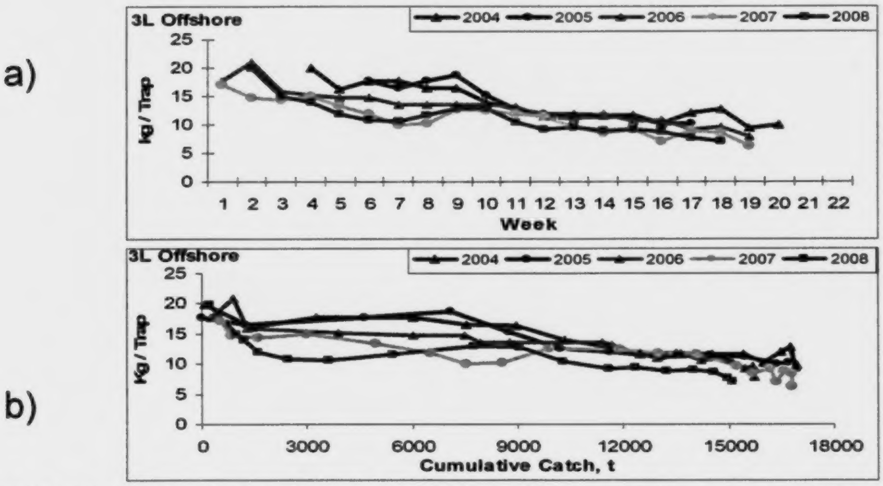


Figure 110. Seasonal trends in logbook-based CPUE for Division 3L offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

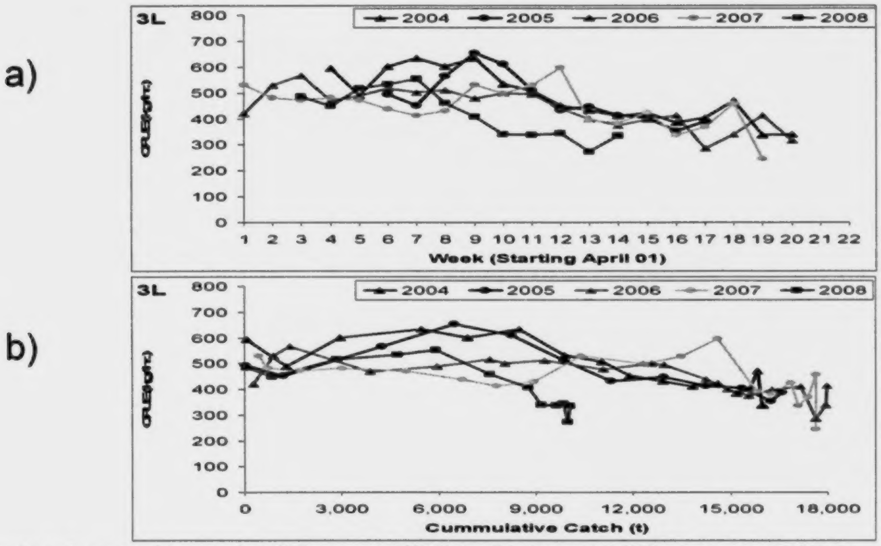


Figure 111. Seasonal trends in VMS-based CPUE for Division 3L offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

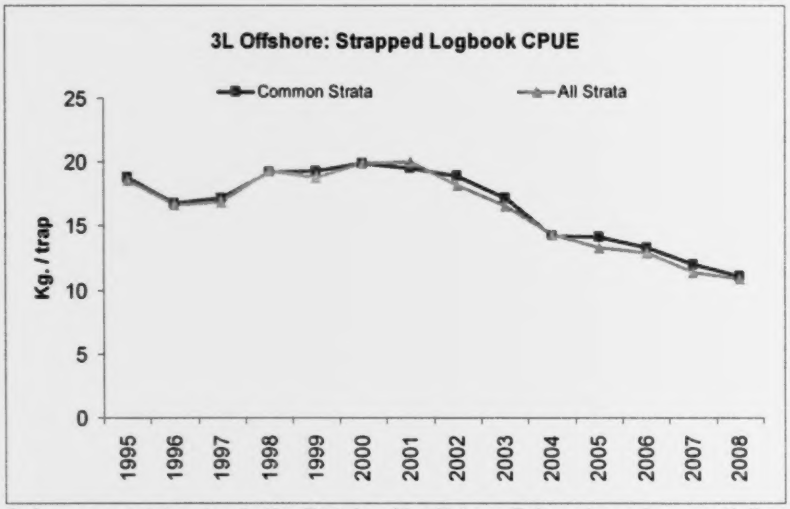


Figure 112. Trends in mean catch rates in the Division 3L offshore fishery based on spatially-expanded logbook STRAP analysis.

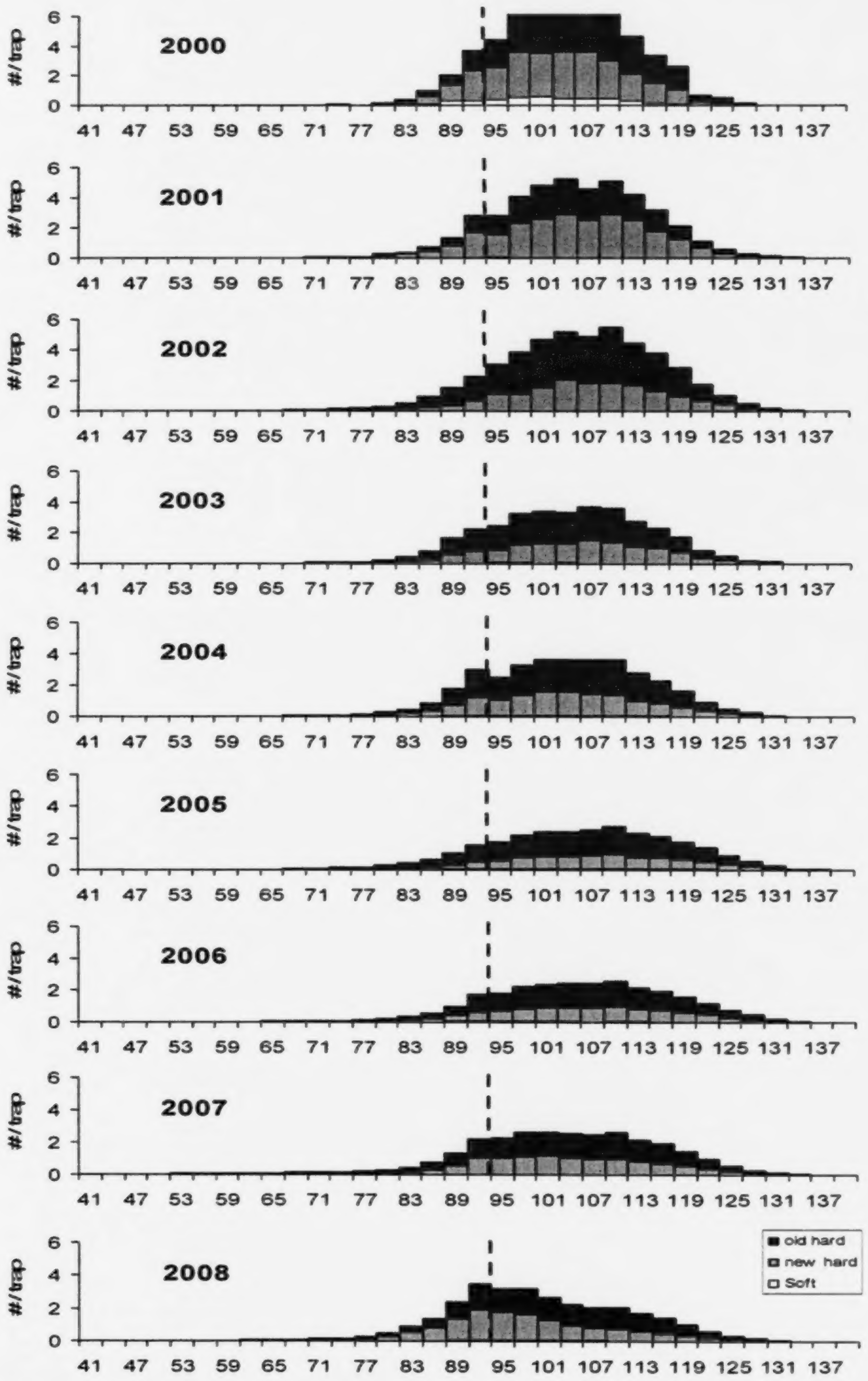


Figure 113. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3L offshore. The vertical dashed line indicates the minimum legal size.

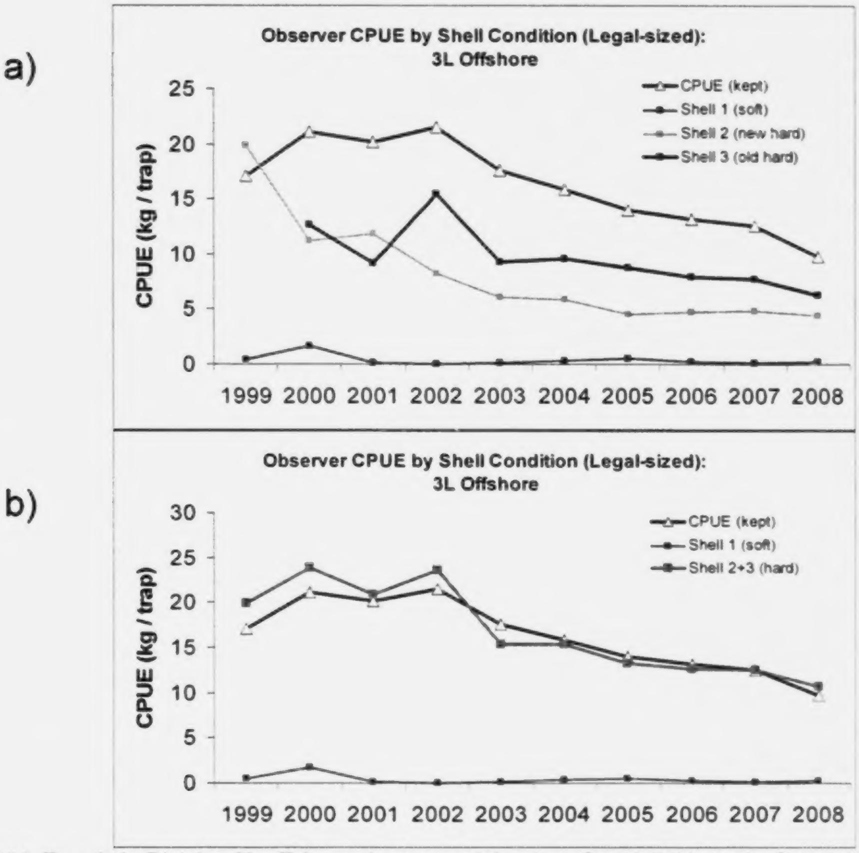


Figure 114. Trends in Division 3L offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

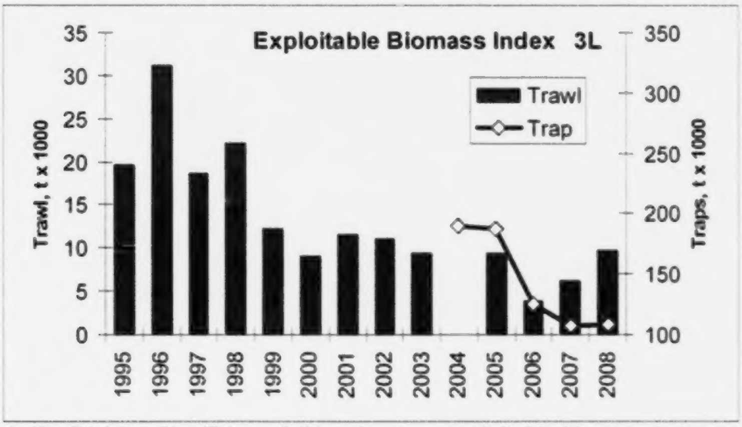


Figure 115. Trends in the Division 3L offshore fall trawl survey exploitable biomass index and the post-season survey biomass index. The survey was incomplete in 2004.

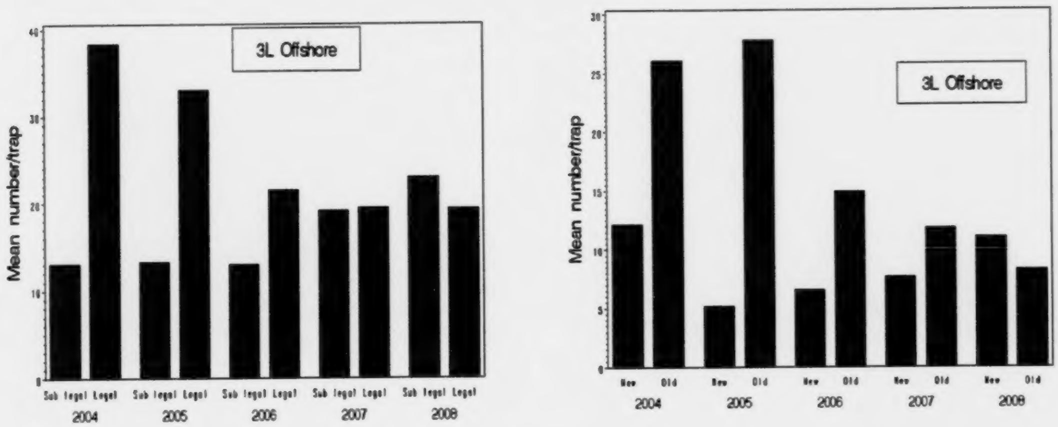


Figure 116. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 3L offshore industry-DFO collaborative post-season trap survey.

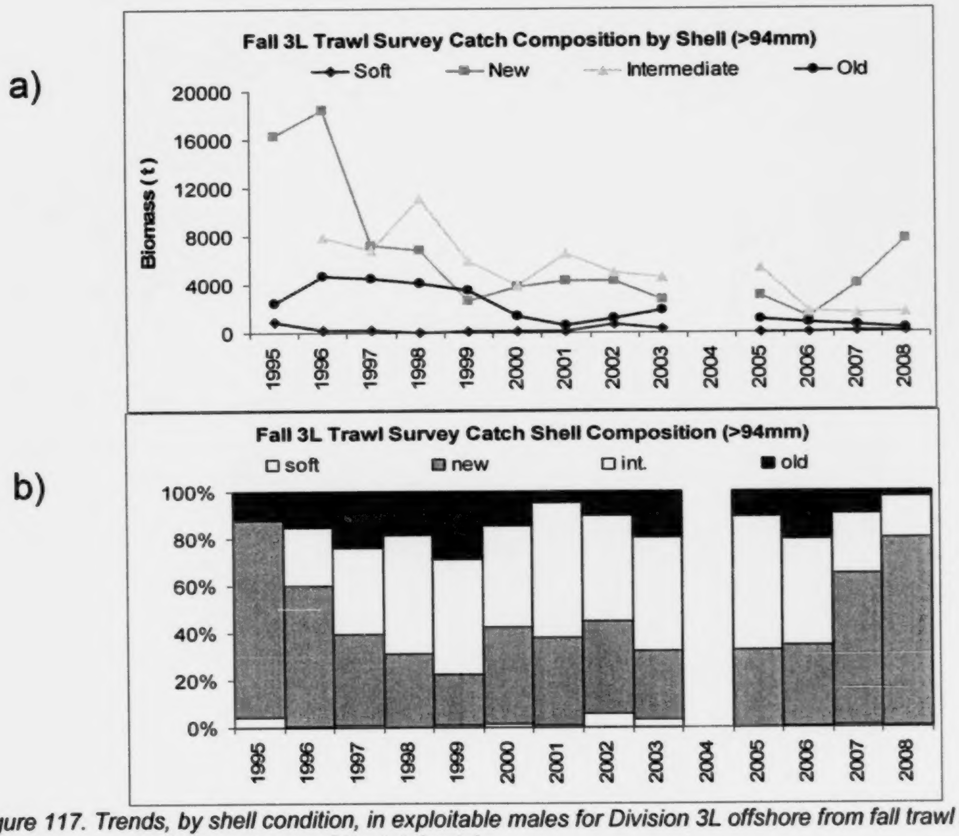


Figure 117. Trends, by shell condition, in exploitable males for Division 3L offshore from fall trawl surveys for; (a) biomass, and (b) percentages of the total catch.

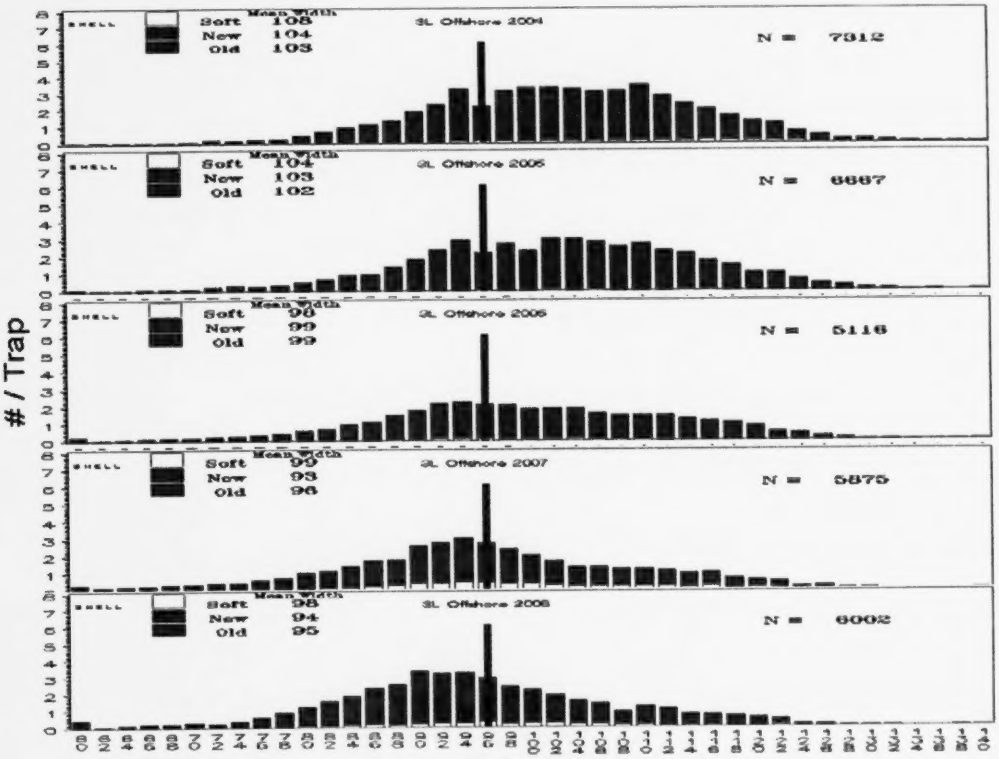


Figure 118. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Division 3L offshore (all stations). The vertical solid line indicates the minimum legal size.

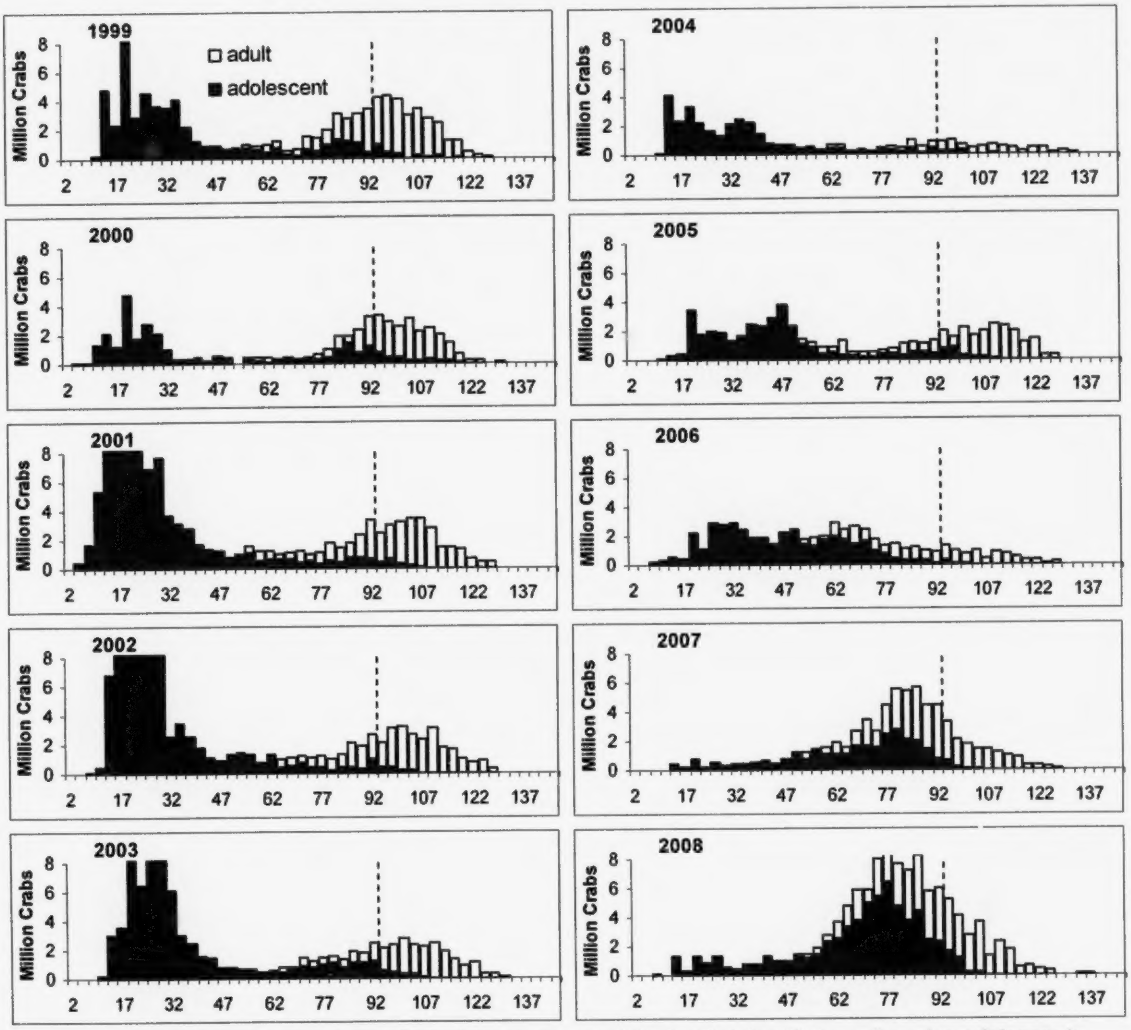


Figure 119. Distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2004.

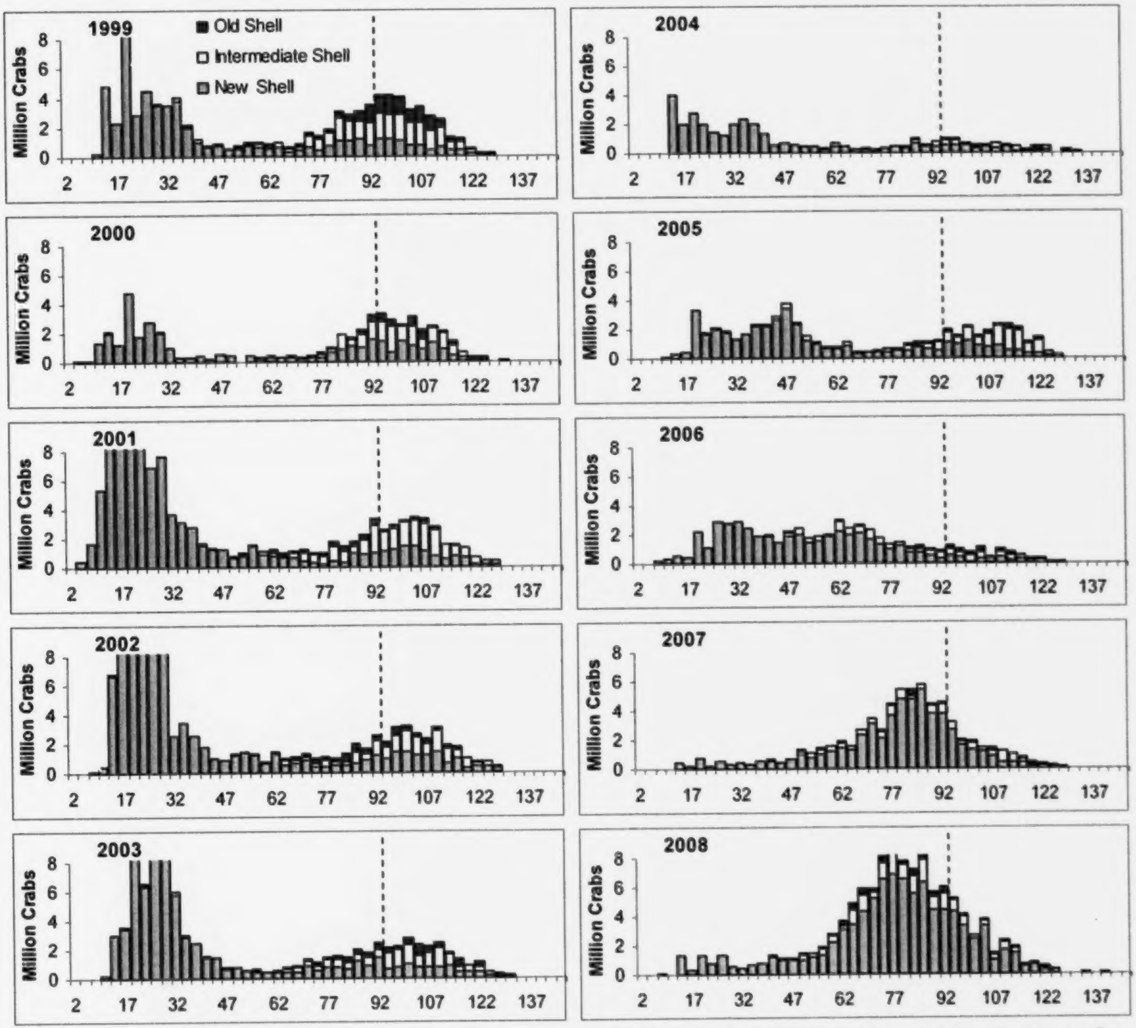


Figure 120. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 3L. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2004.

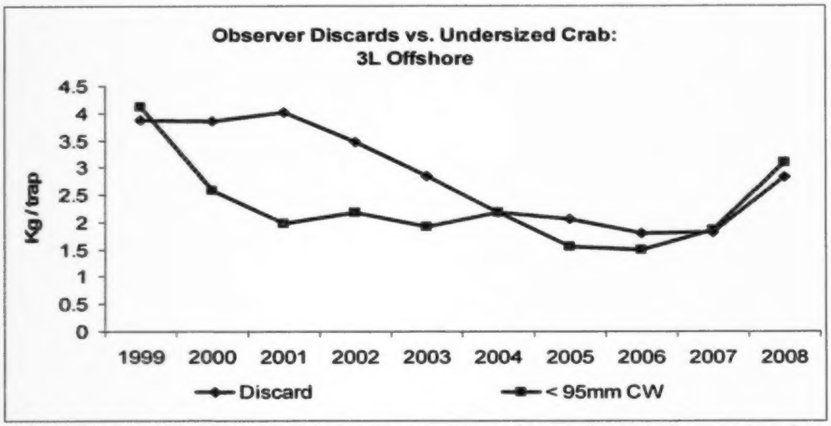


Figure 121. Trends in Division 3L offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

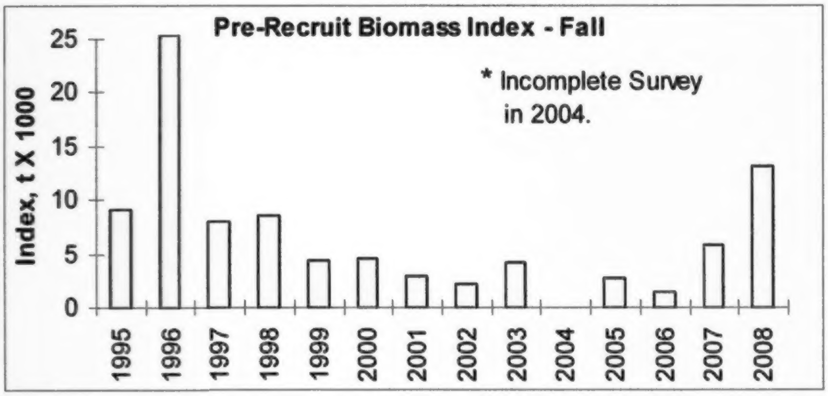


Figure 122. Trends in the Division 3L fall trawl survey pre-recruit biomass index. The survey was incomplete in 2004.

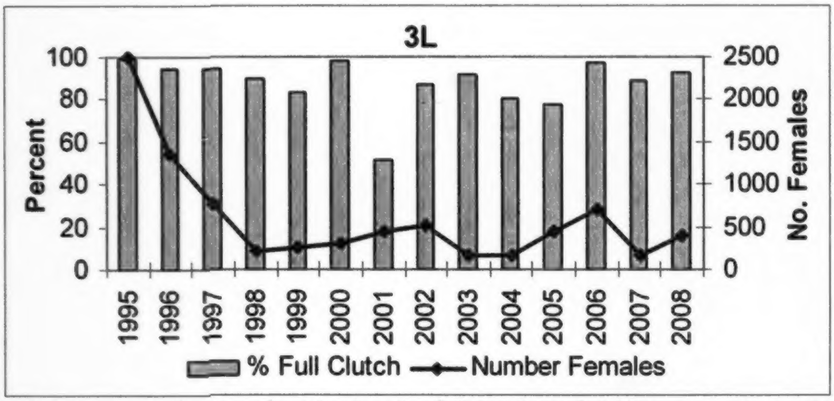


Figure 123. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3L from fall multi-species surveys. The survey was incomplete in 2004.

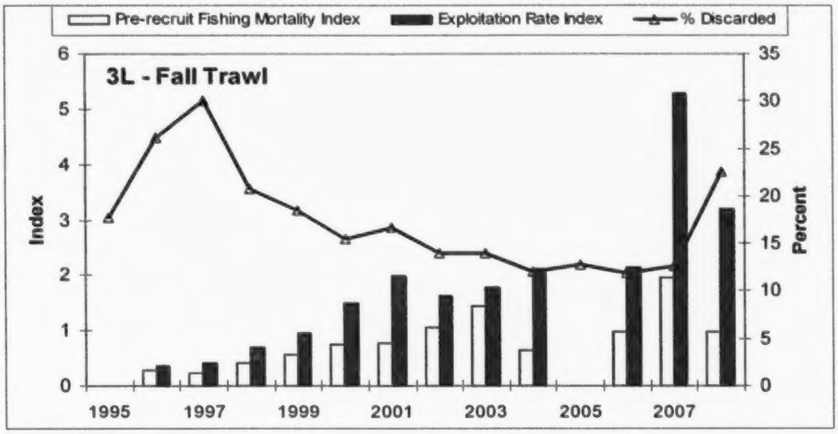


Figure 124. Trends in Division 3L offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (No 2005 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2004 survey).

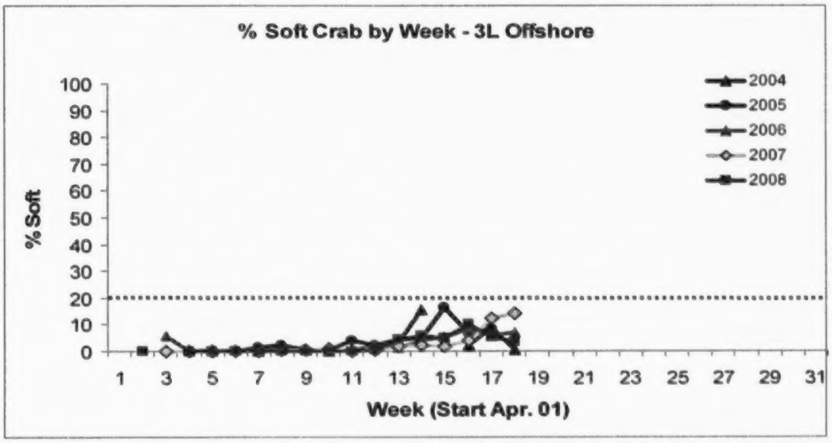


Figure 125. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3L offshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

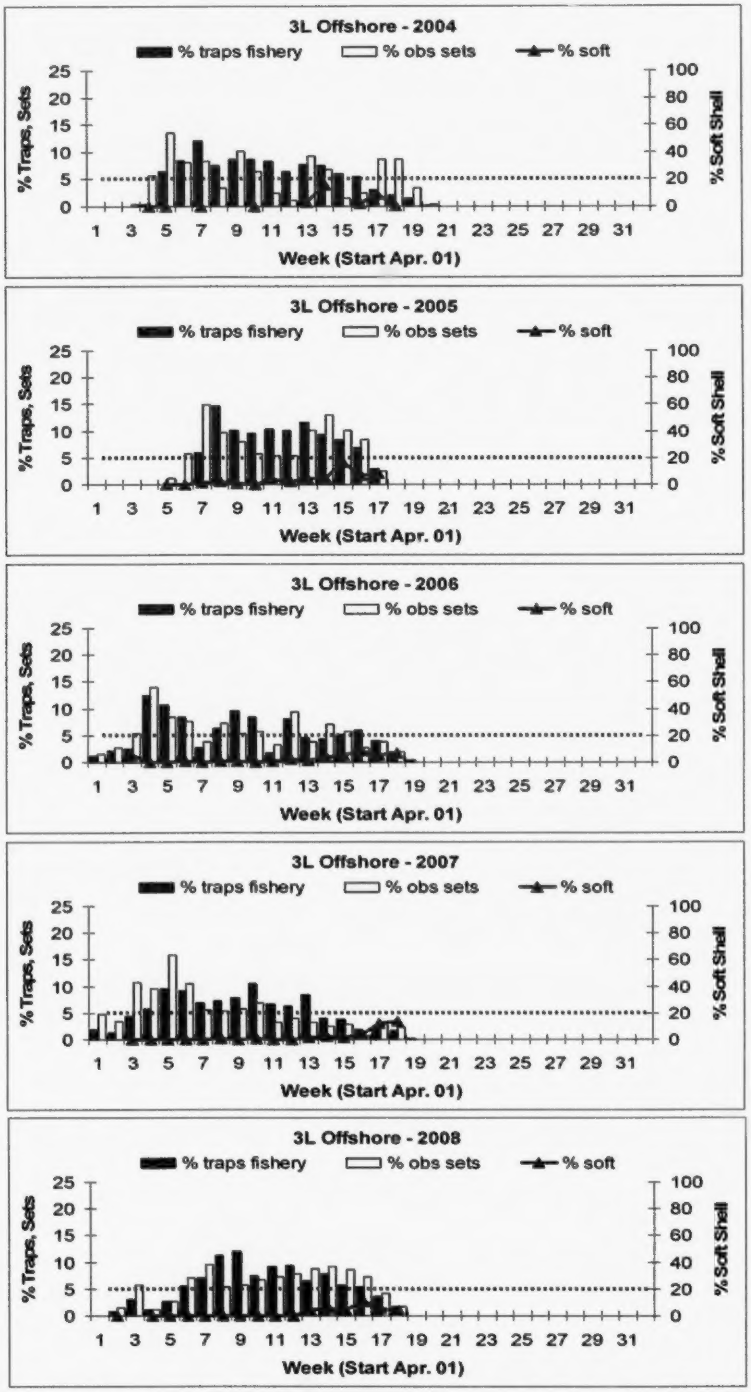


Figure 126. Seasonal trends in Division 3L offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2004-08. (Sample sizes of <10 observed sets/week removed)

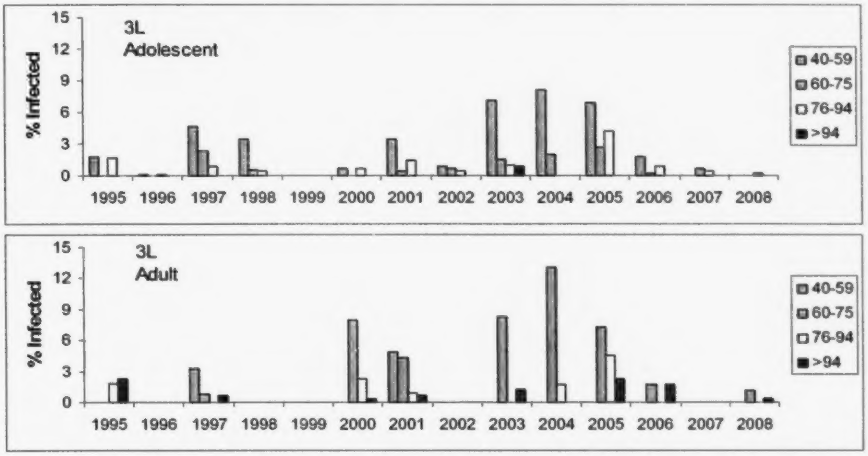


Figure 127. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 3L fall trawl surveys.

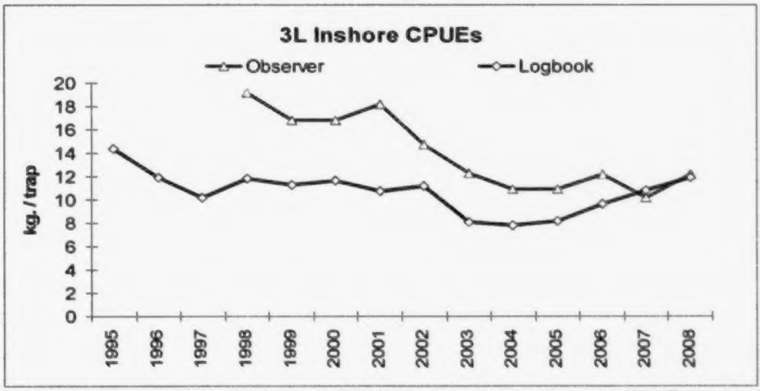


Figure 128. Trends in commercial logbook-based CPUE and observer-based CPUE in the Division 3L inshore fishery.

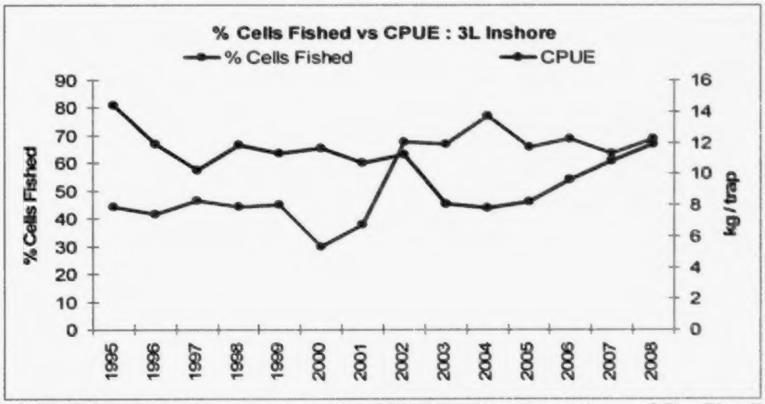


Figure 129. Trends in Division 3L inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

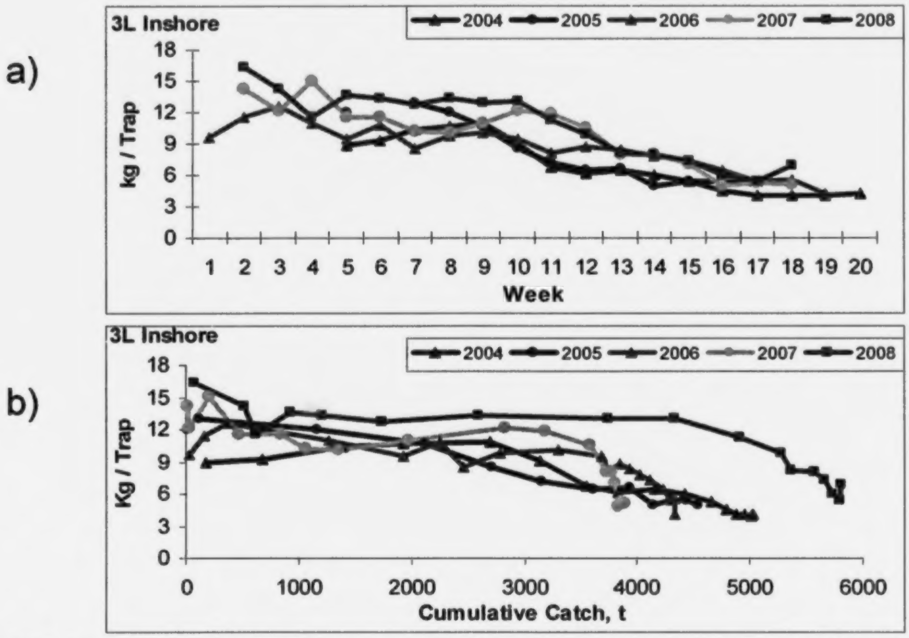


Figure 130. Seasonal trends in logbook-based CPUE for Division 3L inshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

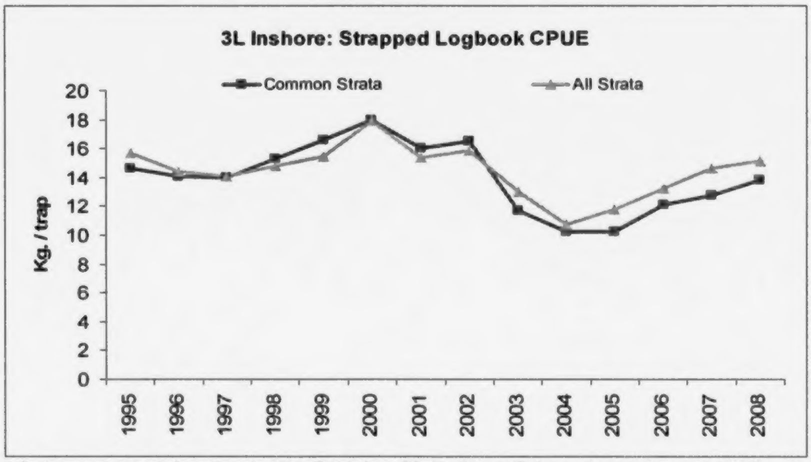


Figure 131. Trends in mean catch rates in the Division 3L inshore fishery based on spatially-expanded logbook STRAP analysis.

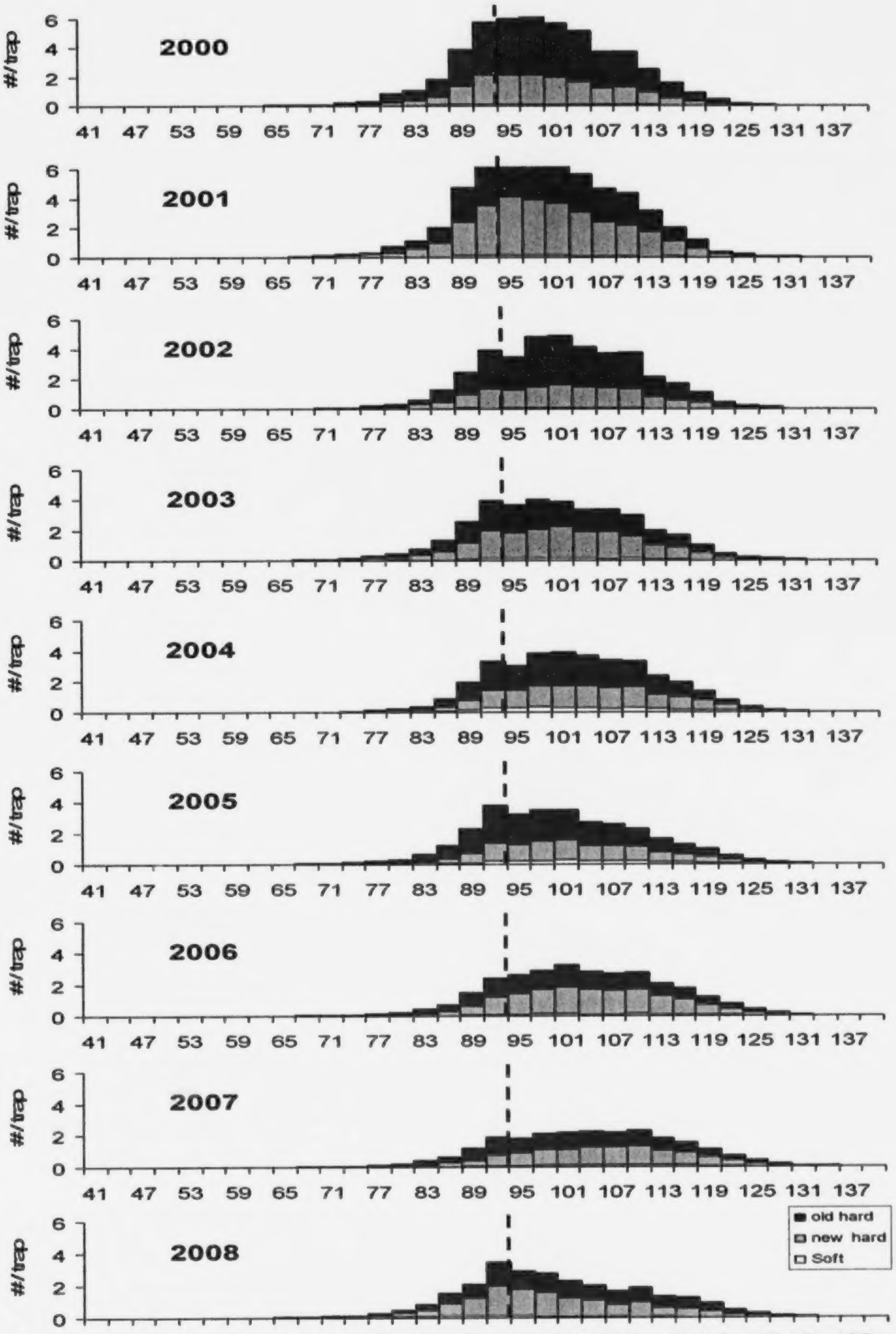


Figure 132. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3L inshore. The vertical dashed line indicates the minimum legal size.

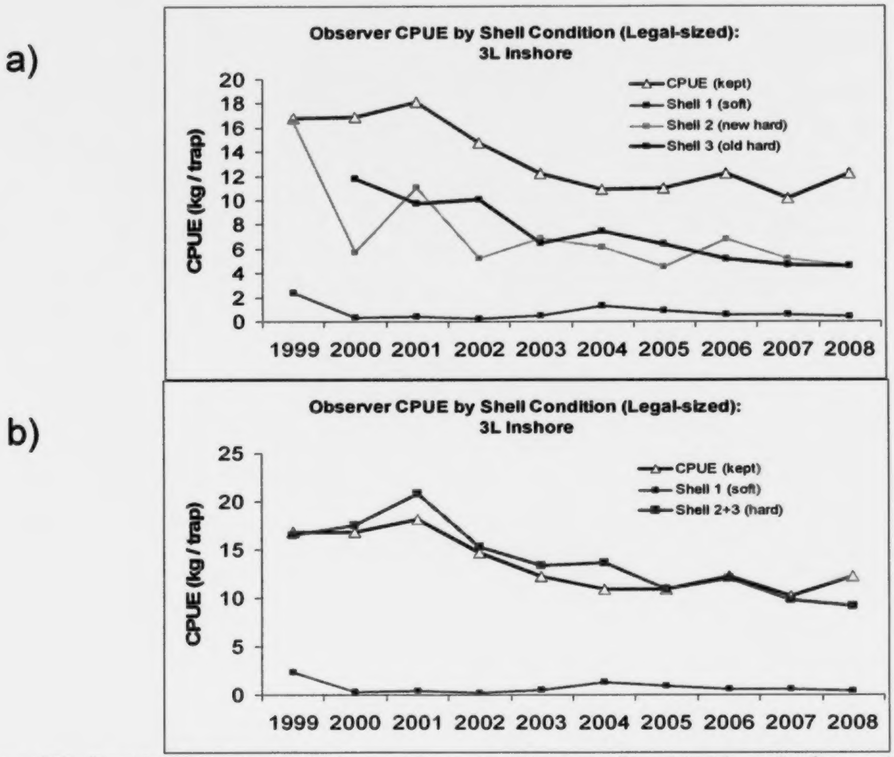


Figure 133. Trends in Division 3L inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

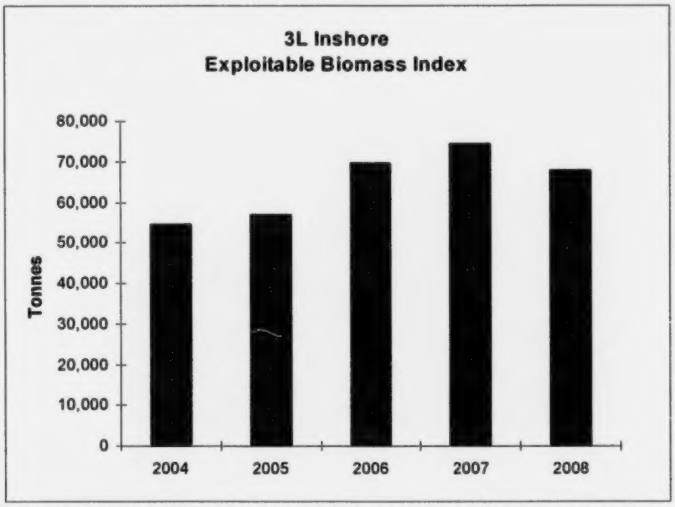


Figure 134. Exploitable biomass index based on the collaborative post-season trap survey in inshore Division 3L.

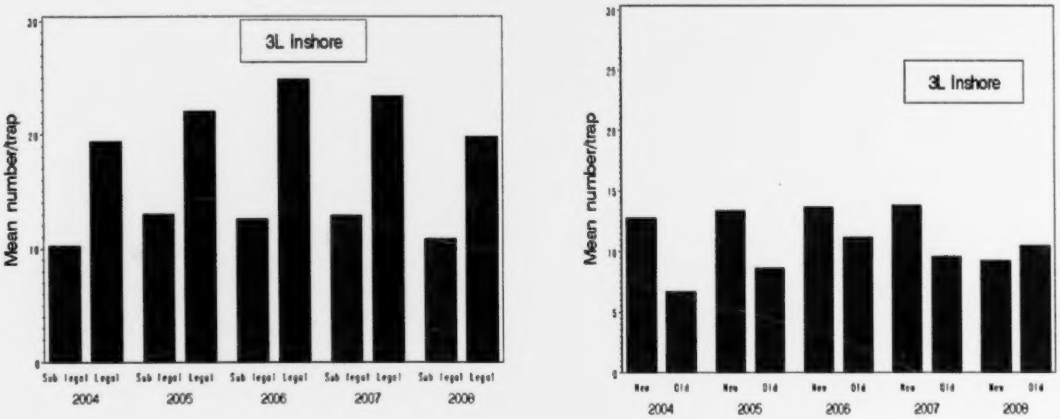


Figure 135. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 3L inshore industry-DFO collaborative post-season trap survey.

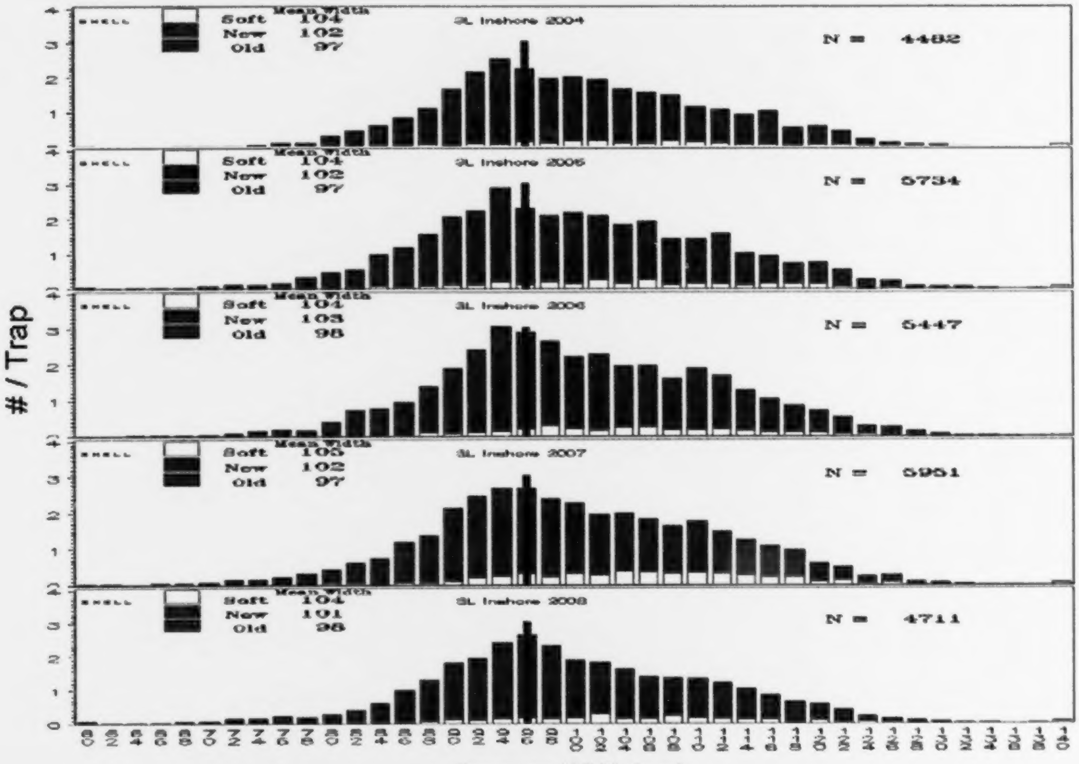


Figure 136. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Division 3L inshore.

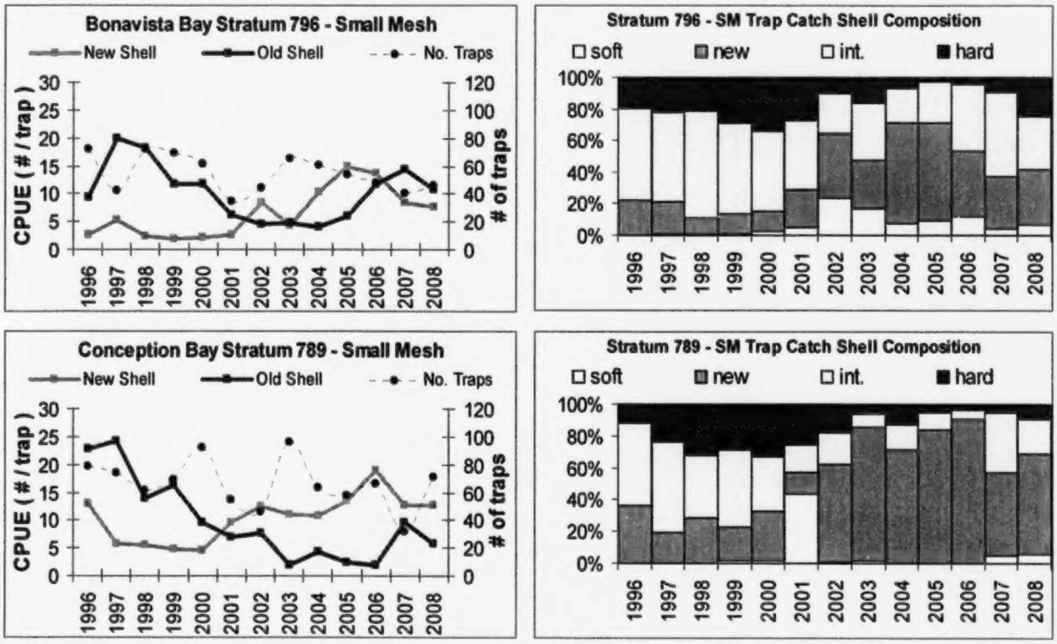


Figure 137a. Trends from small-mesh traps in shell condition of catches by stratum from inshore Division 3L trap surveys in Bonavista Bay (top panels) and Conception Bay (bottom panels), 1996-2008.

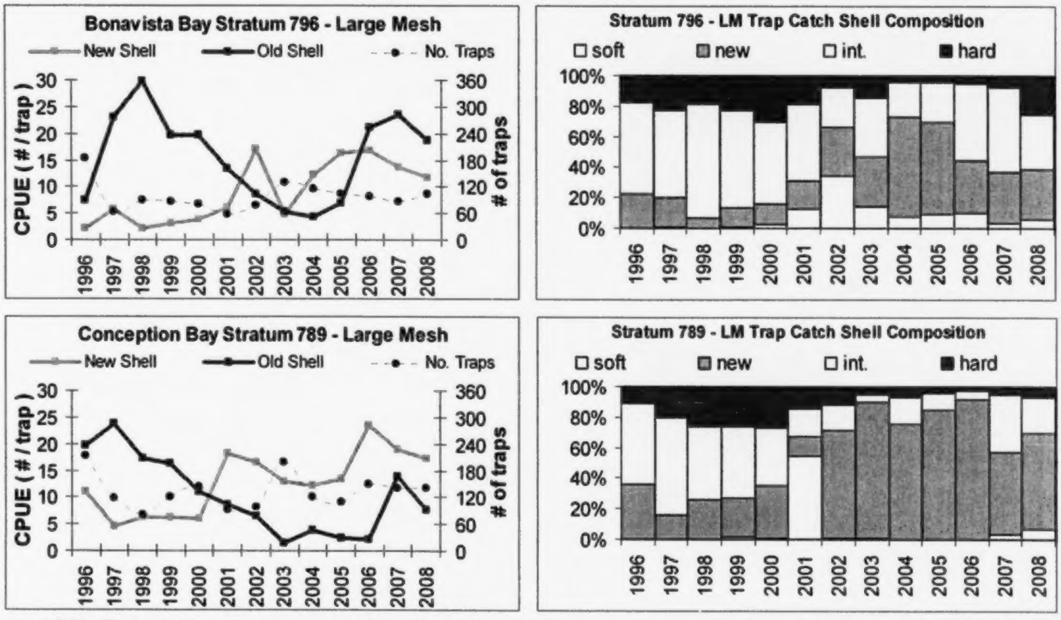


Figure 137b. Trends from large-mesh traps in shell condition of catches by stratum from inshore Division 3L trap surveys in Bonavista Bay (top panels) and Conception Bay (bottom panels), 1996-2008.

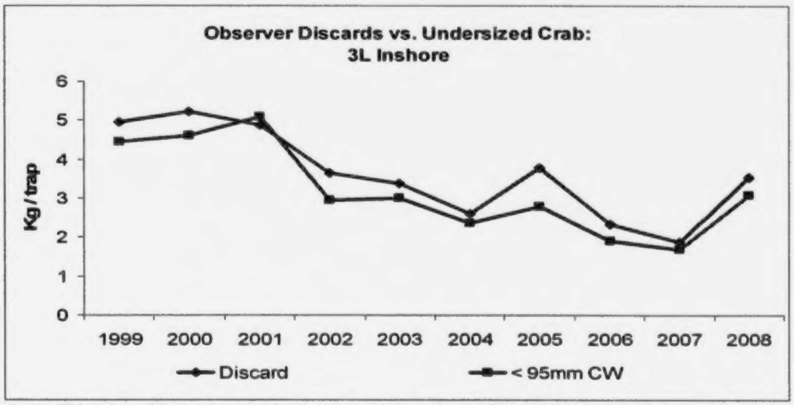


Figure 138. Trends in Division 3L inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

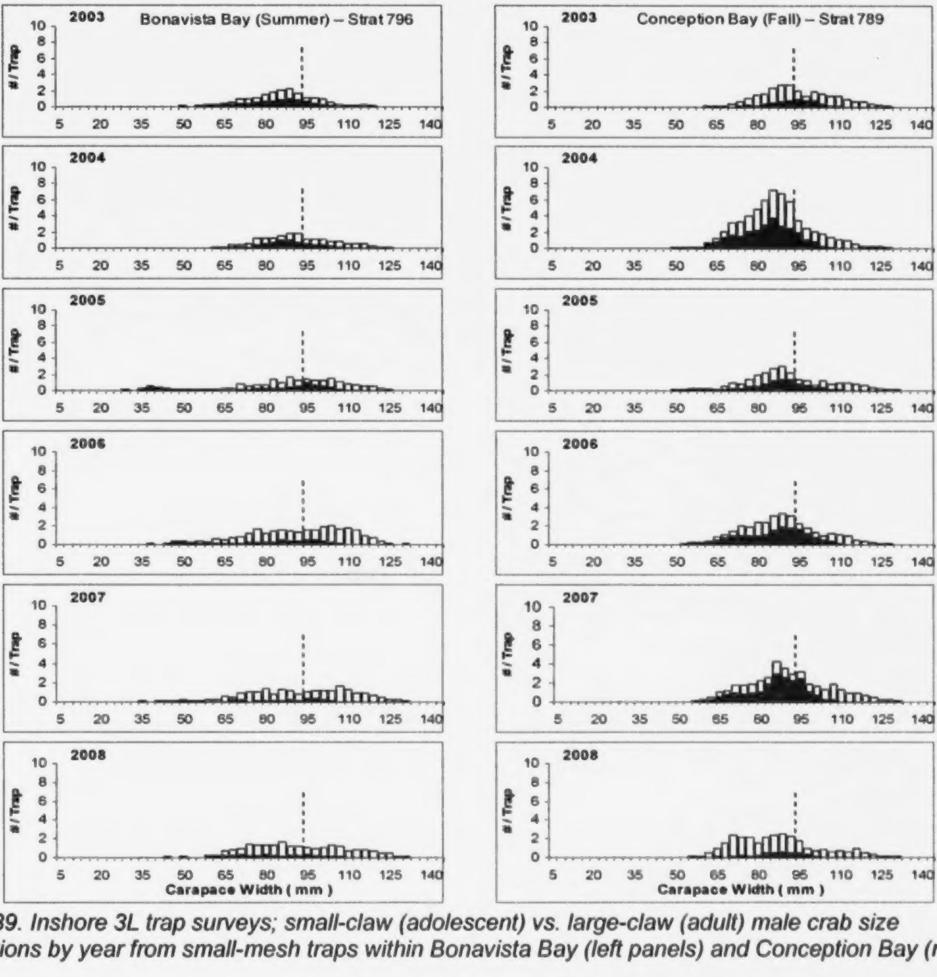


Figure 139. Inshore 3L trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within Bonavista Bay (left panels) and Conception Bay (right panels).

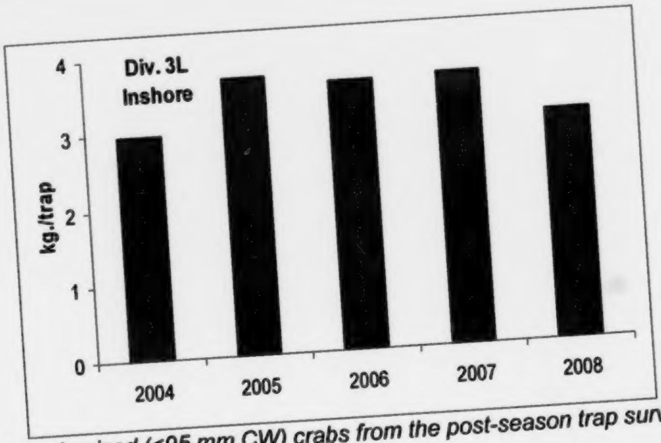


Fig. 140. Catch rates of undersized (<95 mm CW) crabs from the post-season trap survey in inshore Division 3L.

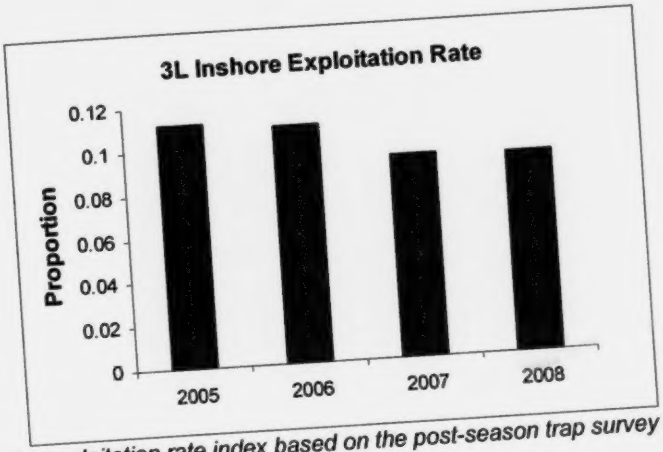


Figure 141. Trends in the exploitation rate index based on the post-season trap survey in Division 3L.

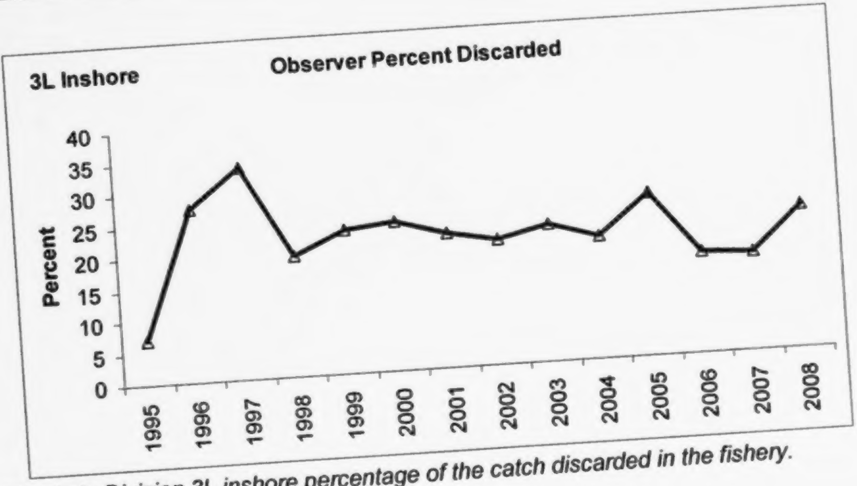


Figure 142. Trends in Division 3L inshore percentage of the catch discarded in the fishery.

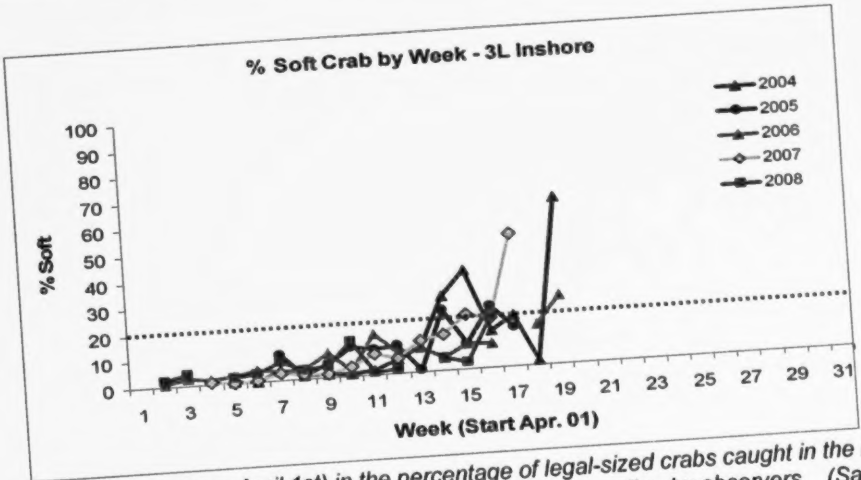


Figure 143. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3L inshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

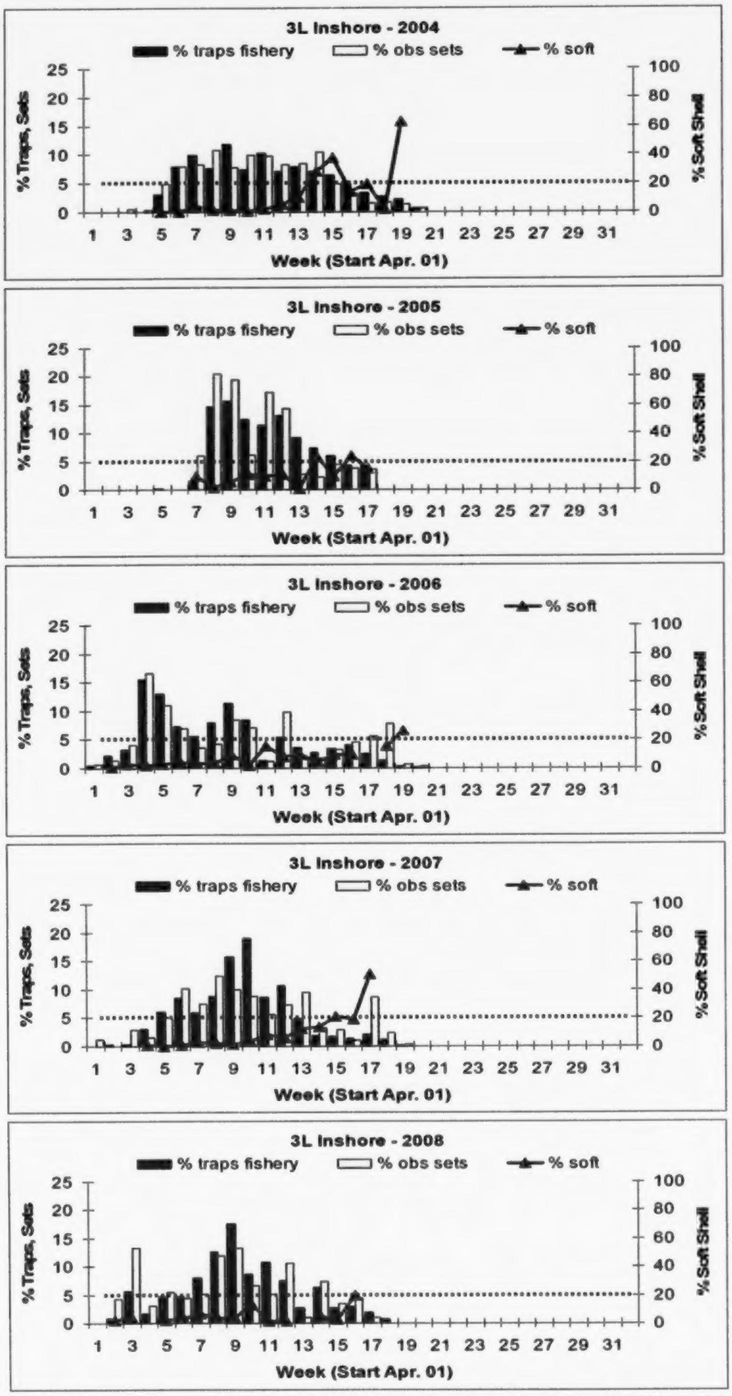


Figure 144. Seasonal trends in Division 3L inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2004-08. (Sample sizes of <10 observed sets/week removed)

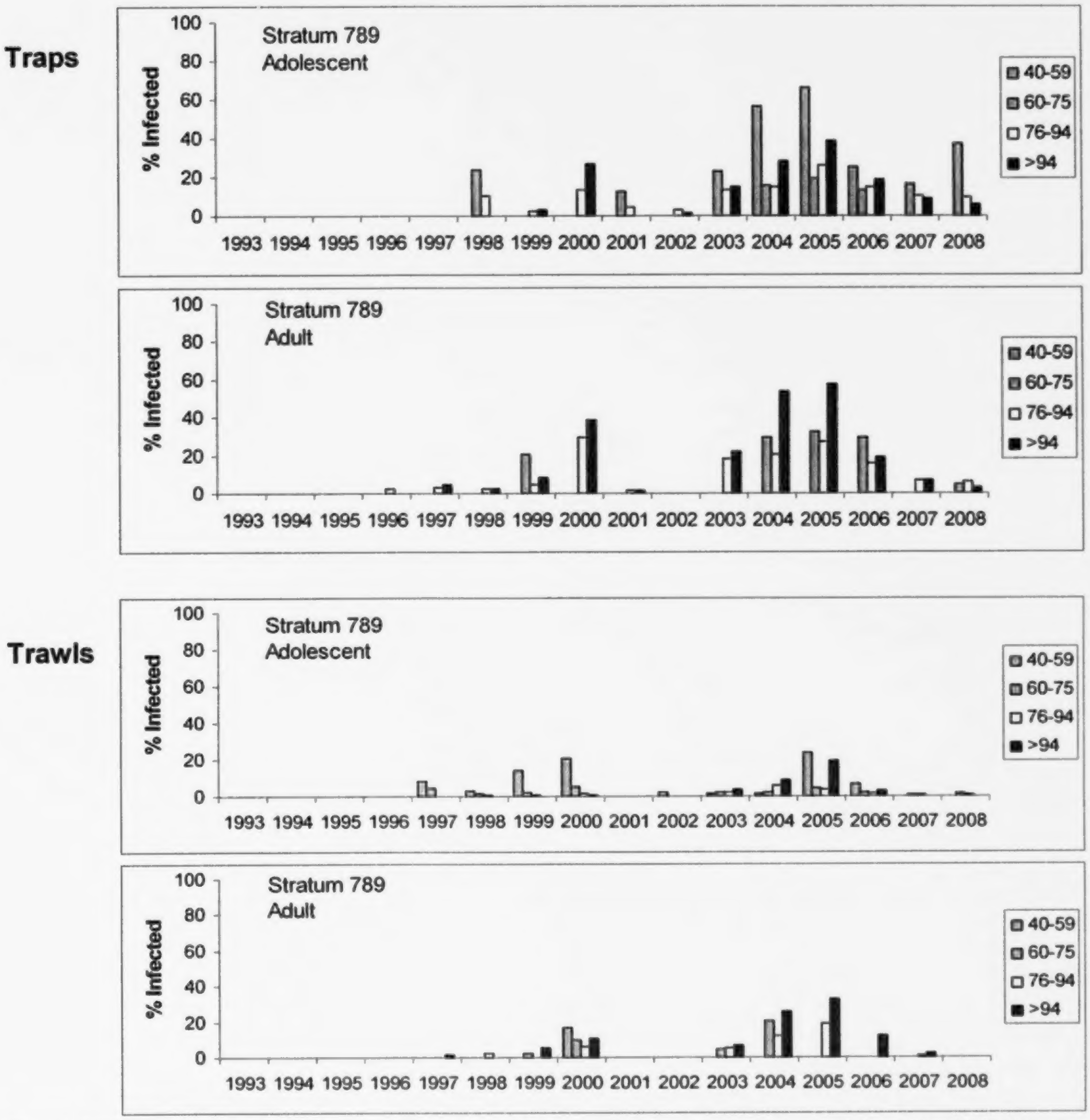


Figure 145. Incidence of BCD by stratum, year, and size group from trap (top panels) and trawl (bottom panels) surveys in Conception Bay; New-shelled males in adolescents (top) and adults (below).

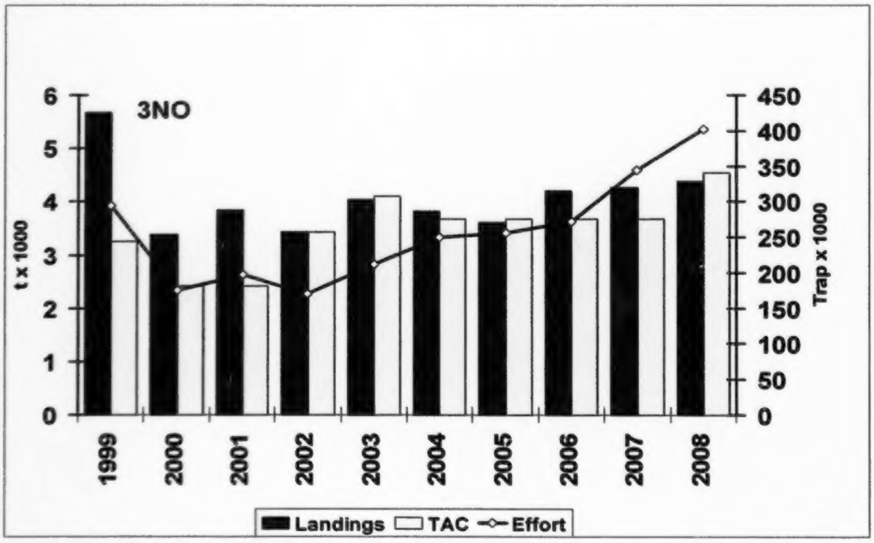


Figure 146. Trends in Division 3NO landings and fishing effort.

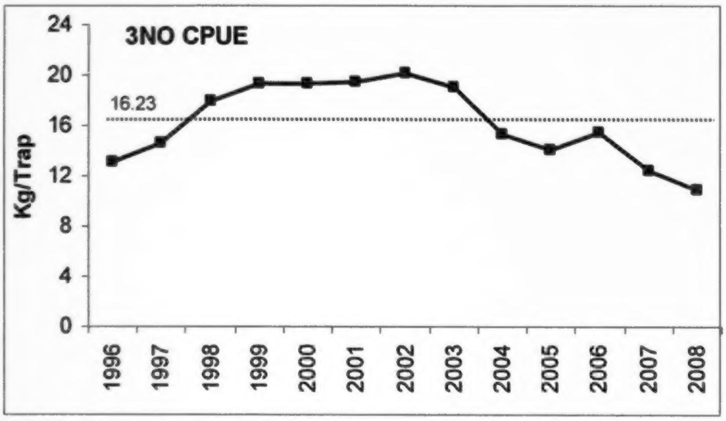


Figure 147. Trends in Division 3NO commercial CPUE in relation to the long-term average (dotted line).

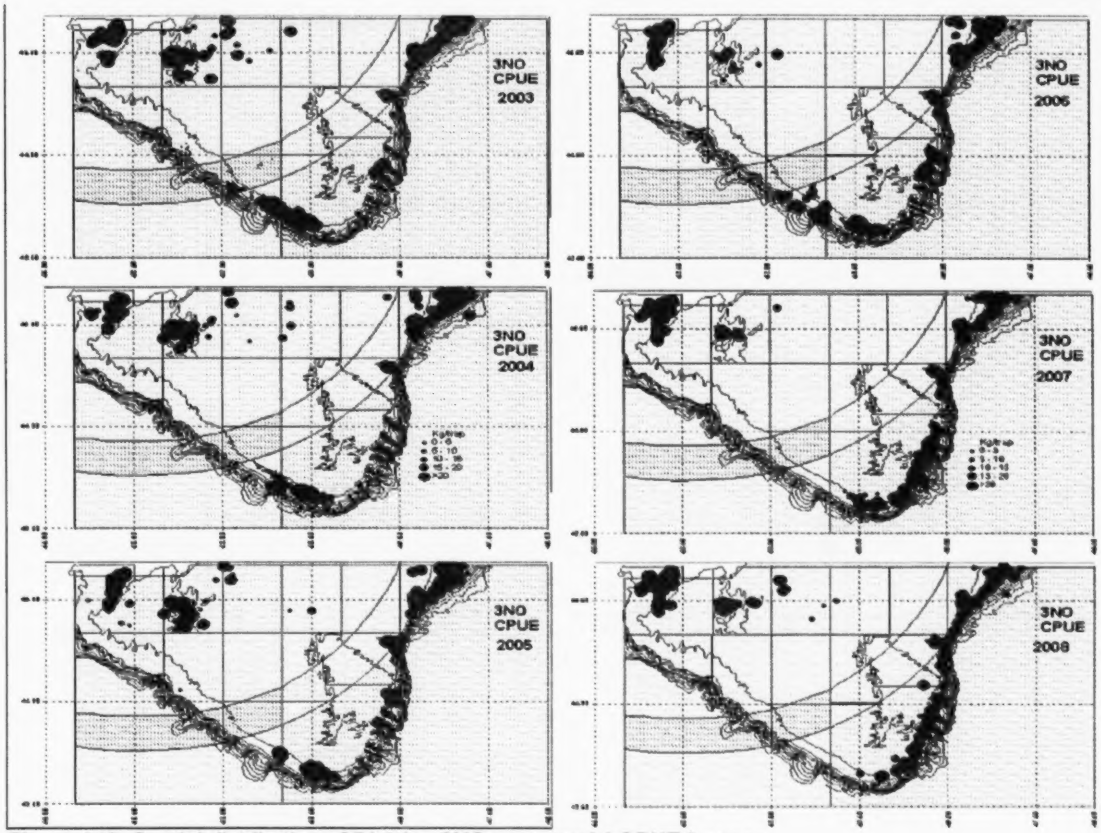

3NO
CPUE
2003
3NO
CPUE
2006
3NO
CPUE
2004
3NO
CPUE
2007
3NO
CPUE
2005
3NO
CPUE
2008

Figure 148. Spatial distribution of Division 3NO commercial CPUE by year.

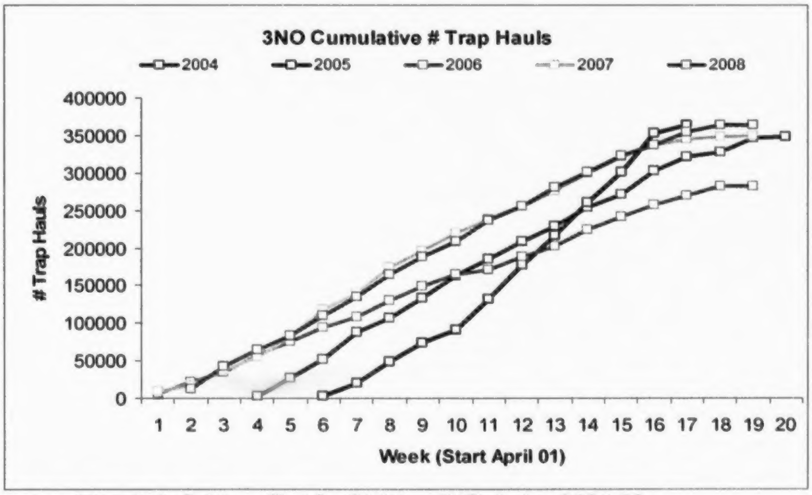


Figure 149. Seasonal trends in fishing effort for Division 3NO during 2004-08.

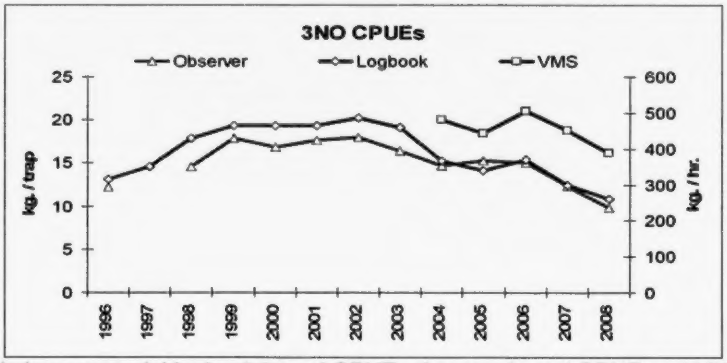


Figure 150. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3NO fishery.

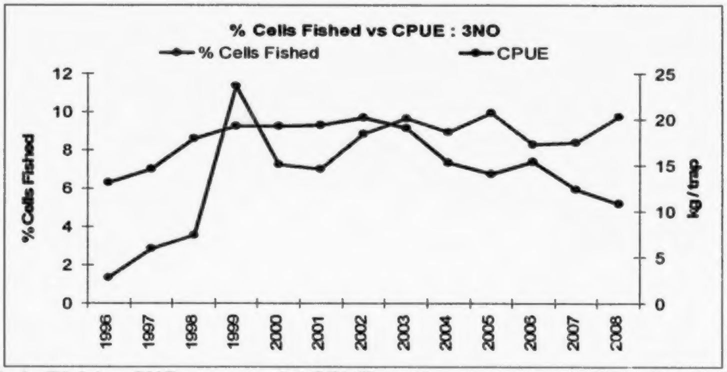


Figure 151. Trends in Division 3NO commercial CPUE vs. the percentage of 5' x 5' cells fished.

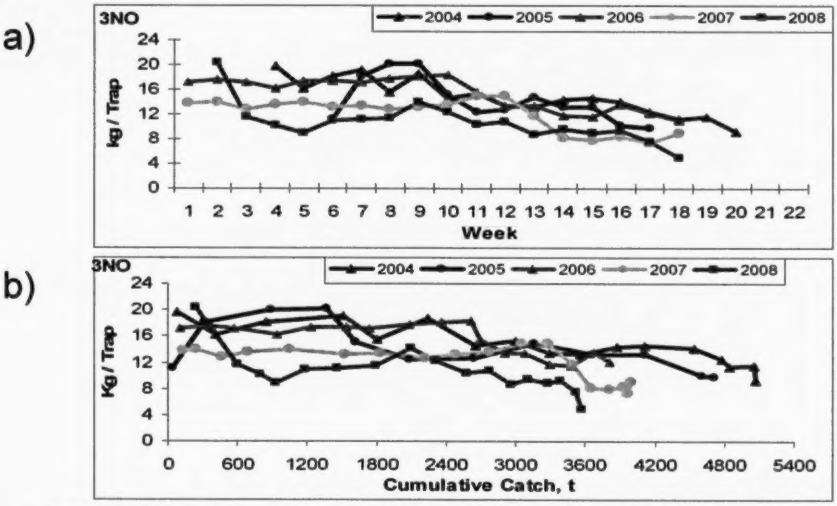


Figure 152. Seasonal trends in logbook-based CPUE for Division 3NO during 2002-07; (a) by week, and (b) in relation to cumulative catch.

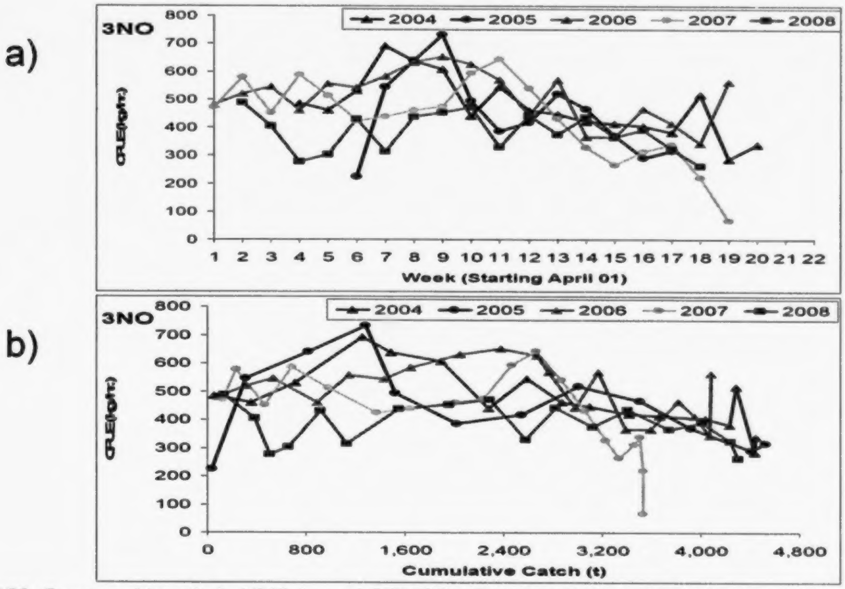


Figure 153. Seasonal trends in VMS-based CPUE for Division 3NO during 2002-07; (a) by week, and (b) in relation to cumulative catch.

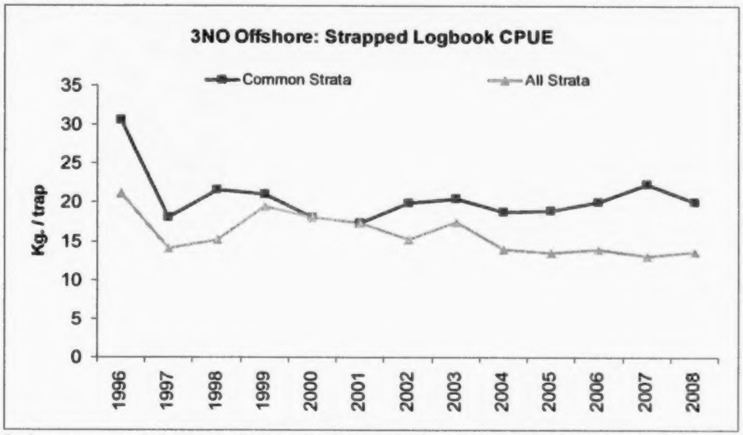


Figure 154. Trends in mean catch rates in the Division 3NO offshore fishery based on spatially-expanded logbook STRAP analysis.

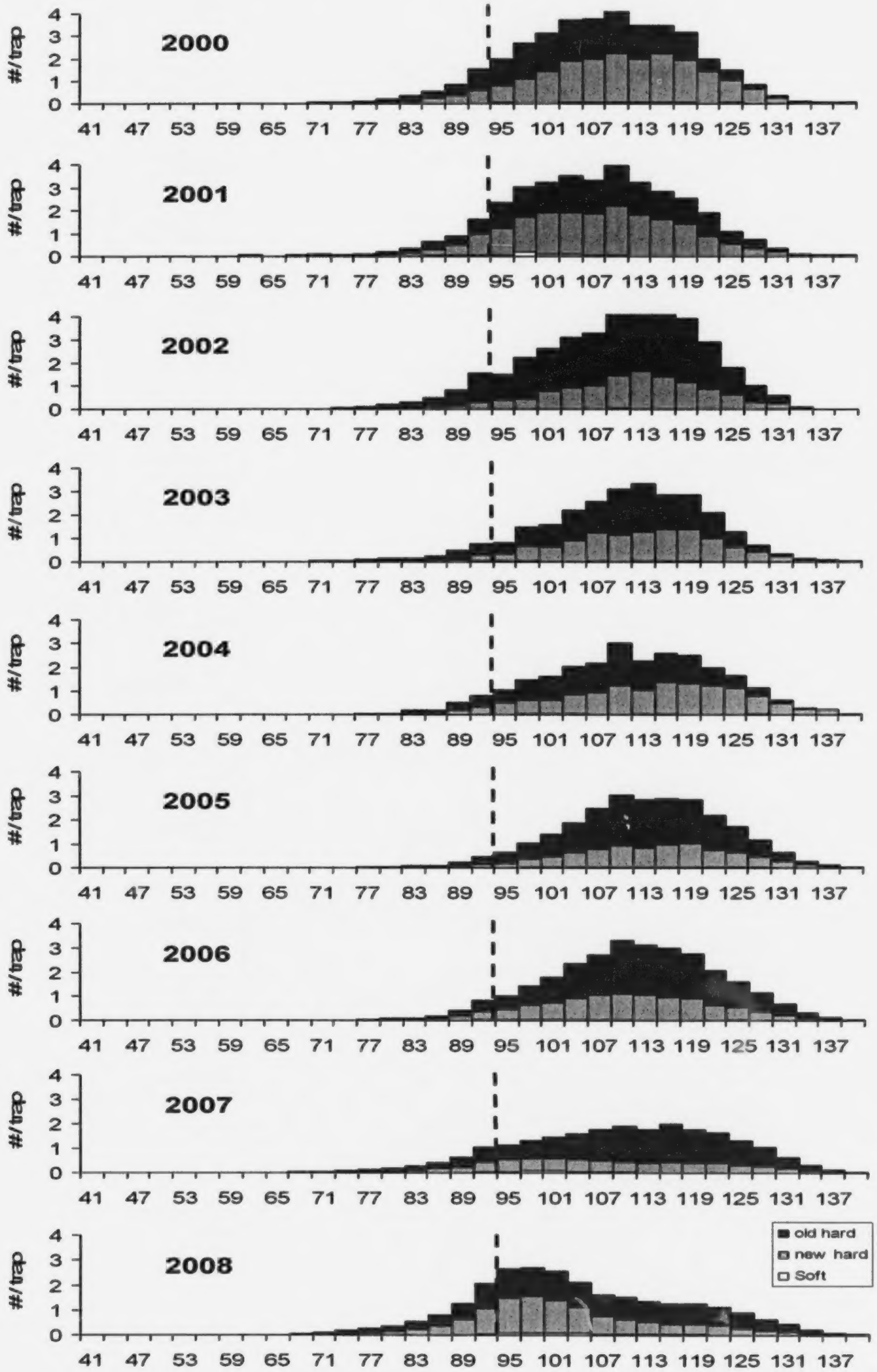


Figure 155. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3NO. The vertical dashed line indicates the minimum legal size.

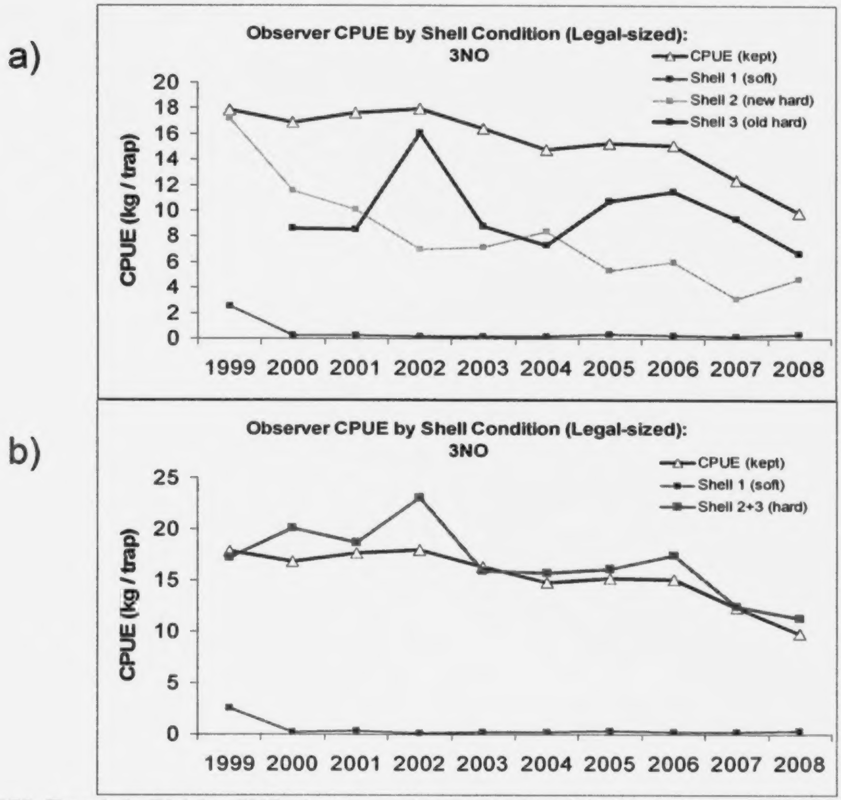


Figure 156. Trends in Division 3NO observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

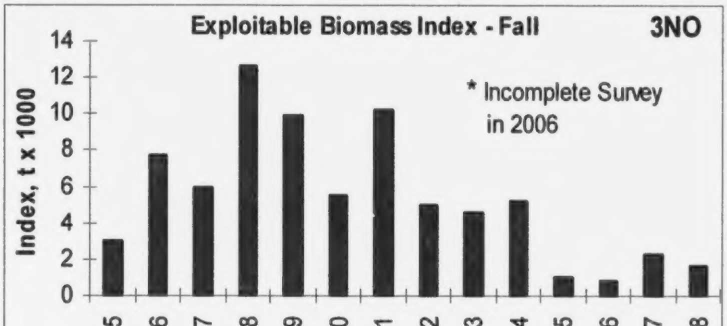


Figure 157. Trends in the Division 3NO fall trawl survey exploitable biomass index. The survey was incomplete in 2006.

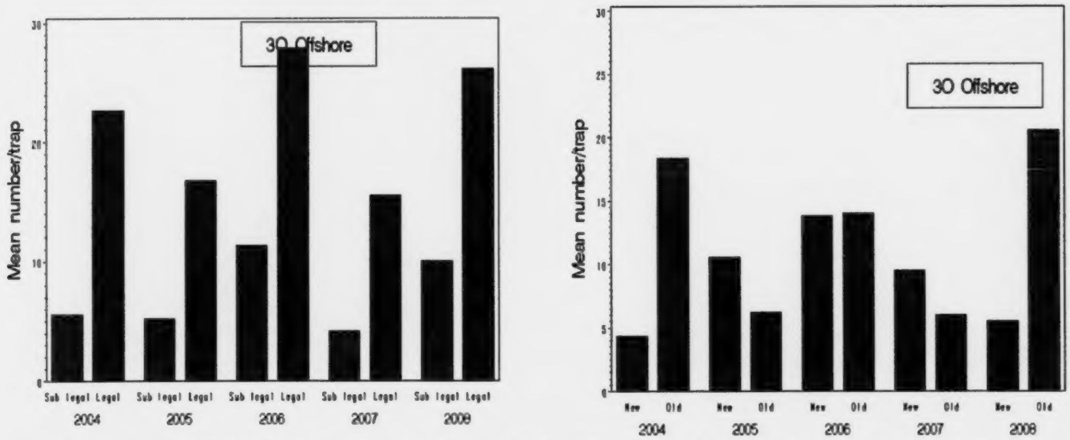


Figure 158. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 3NO inshore industry-DFO collaborative post-season trap survey.

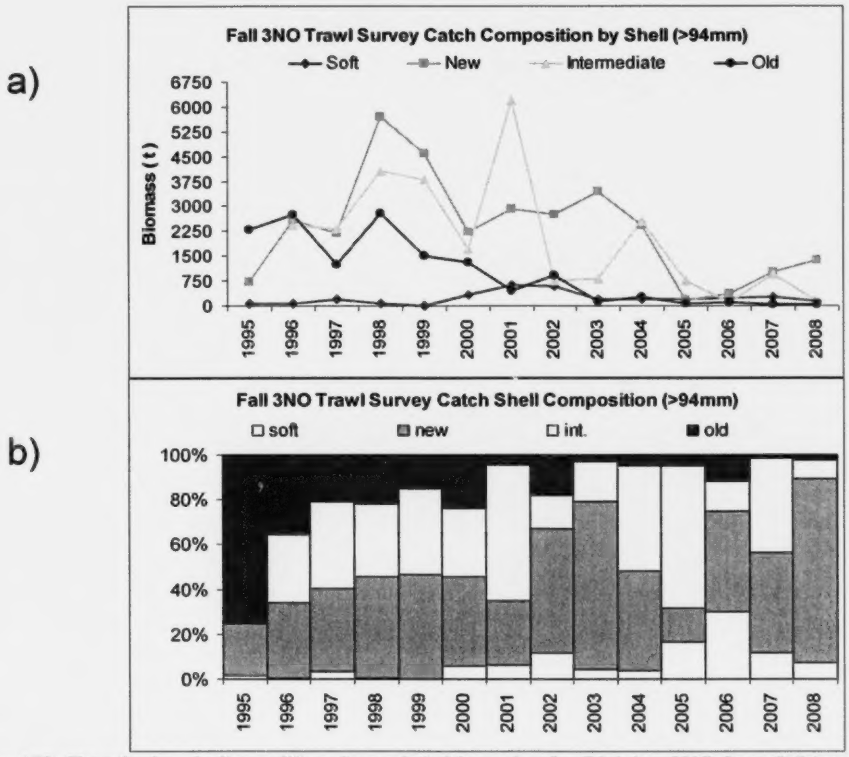


Figure 159. Trends, by shell condition, in exploitable males for Division 3NO from fall trawl surveys for; a) biomass, and (b) percentages of the total catch. The survey was incomplete in 2006.

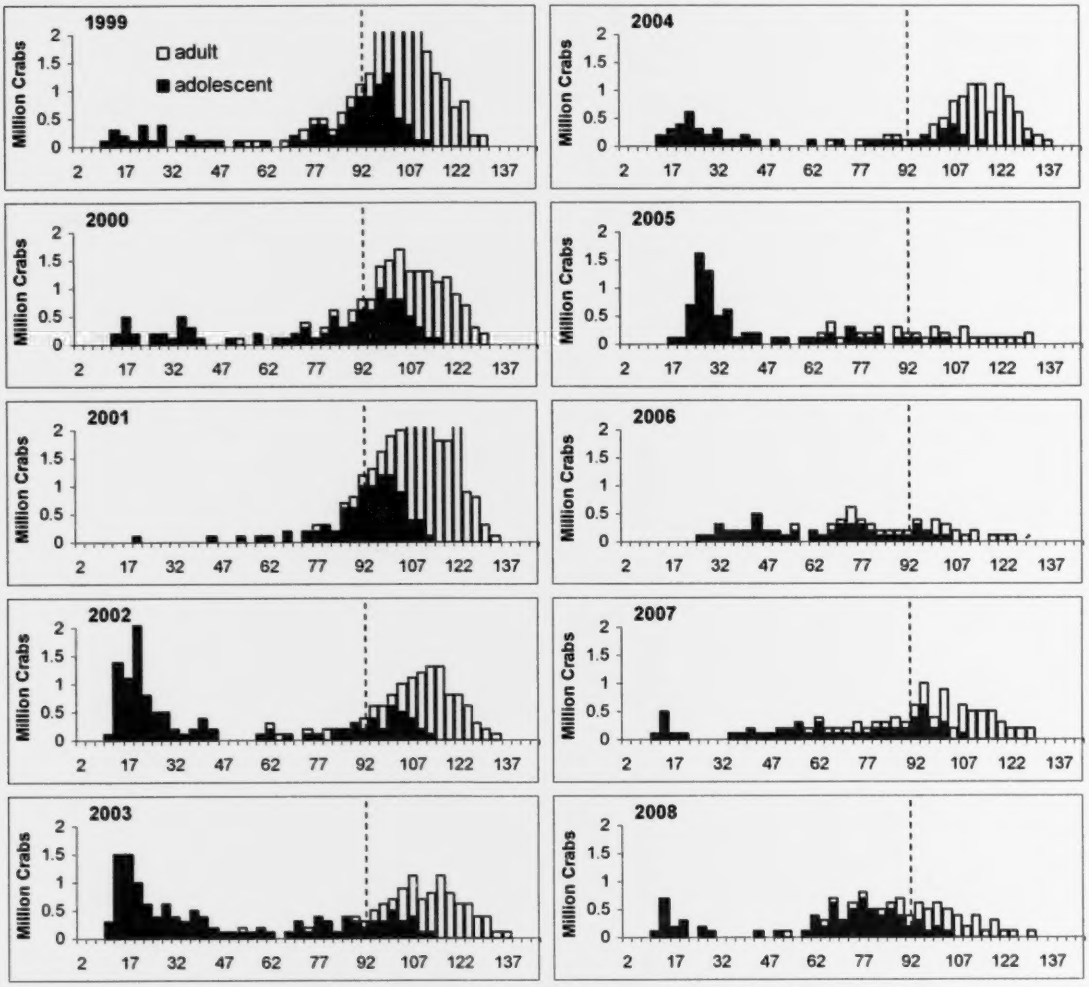


Figure 160. Distribution of abundance (index) by carapace width for Division 3NO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

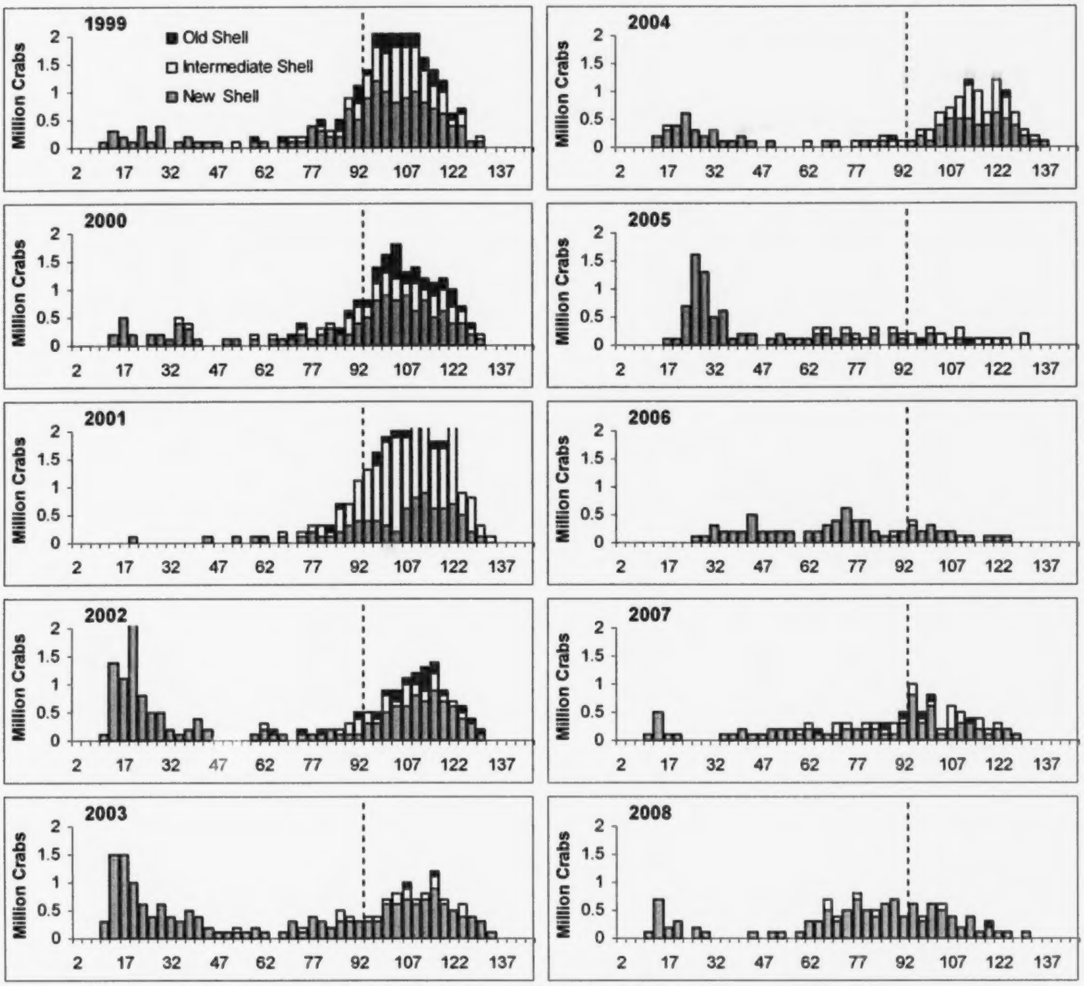


Figure 161. Distribution of abundance (index) by carapace width and shell condition from fall trawl surveys for Division 3NO. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

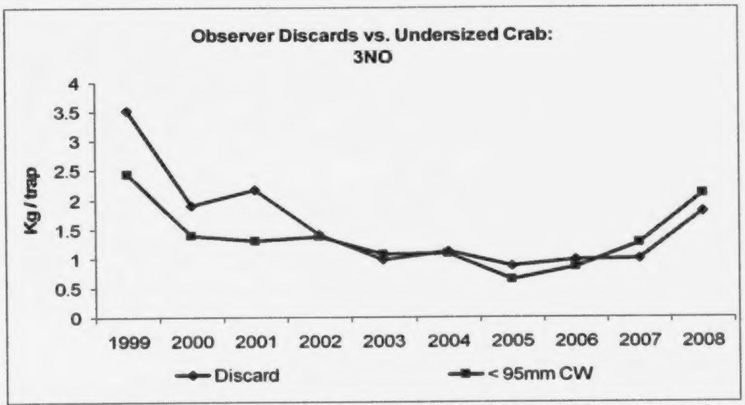


Figure 162. Trends in Division 3NO observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

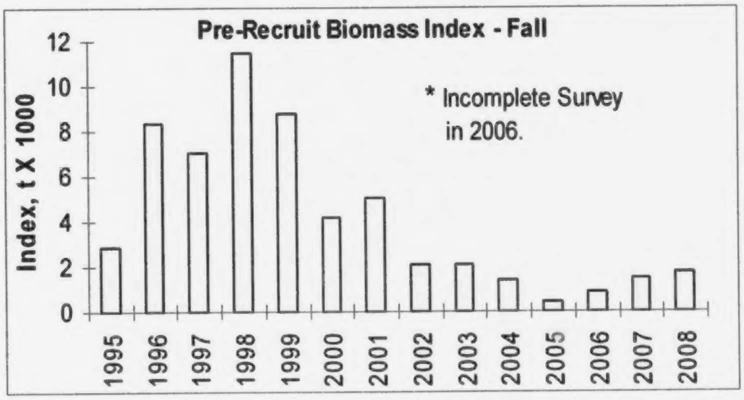


Figure 163. Trends in the Division 3NO fall trawl survey pre-recruit biomass index. The survey was incomplete in 2006.

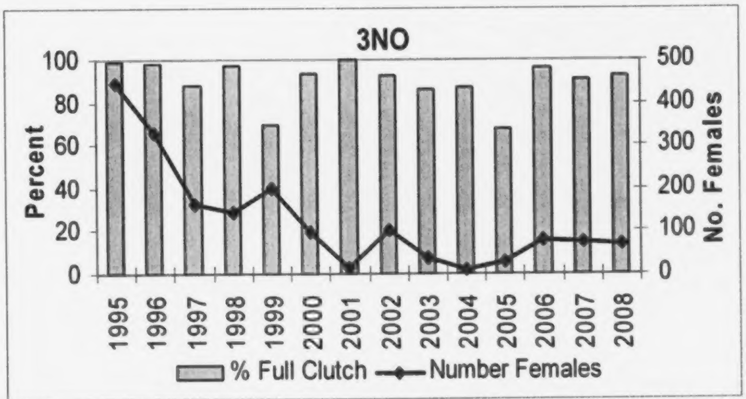


Figure 164. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3NO from fall multi-species surveys. The survey was incomplete in 2006.

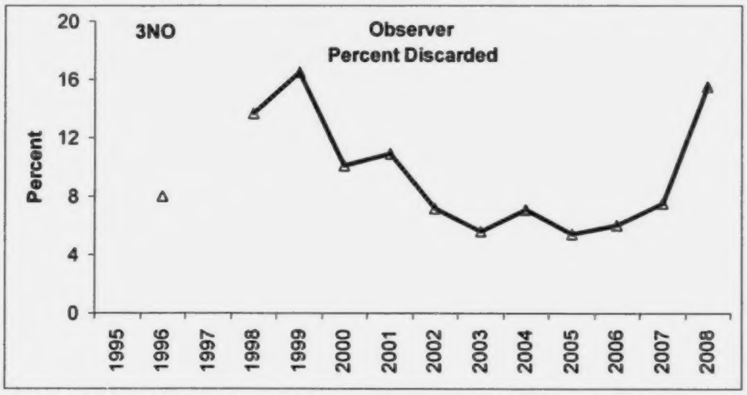


Figure 165. Trends in Division 3NO mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

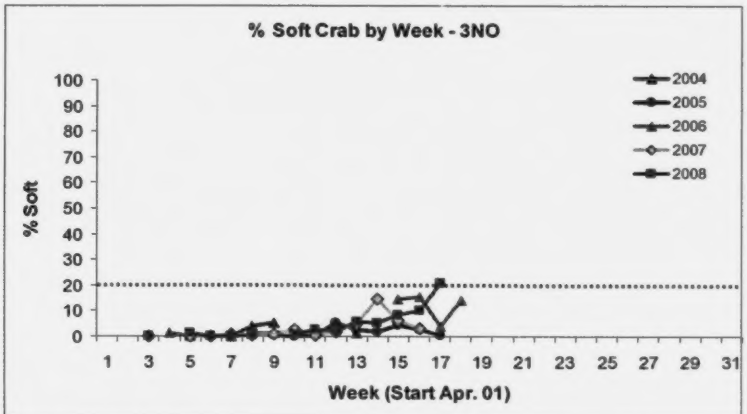


Figure 166. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3NO fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

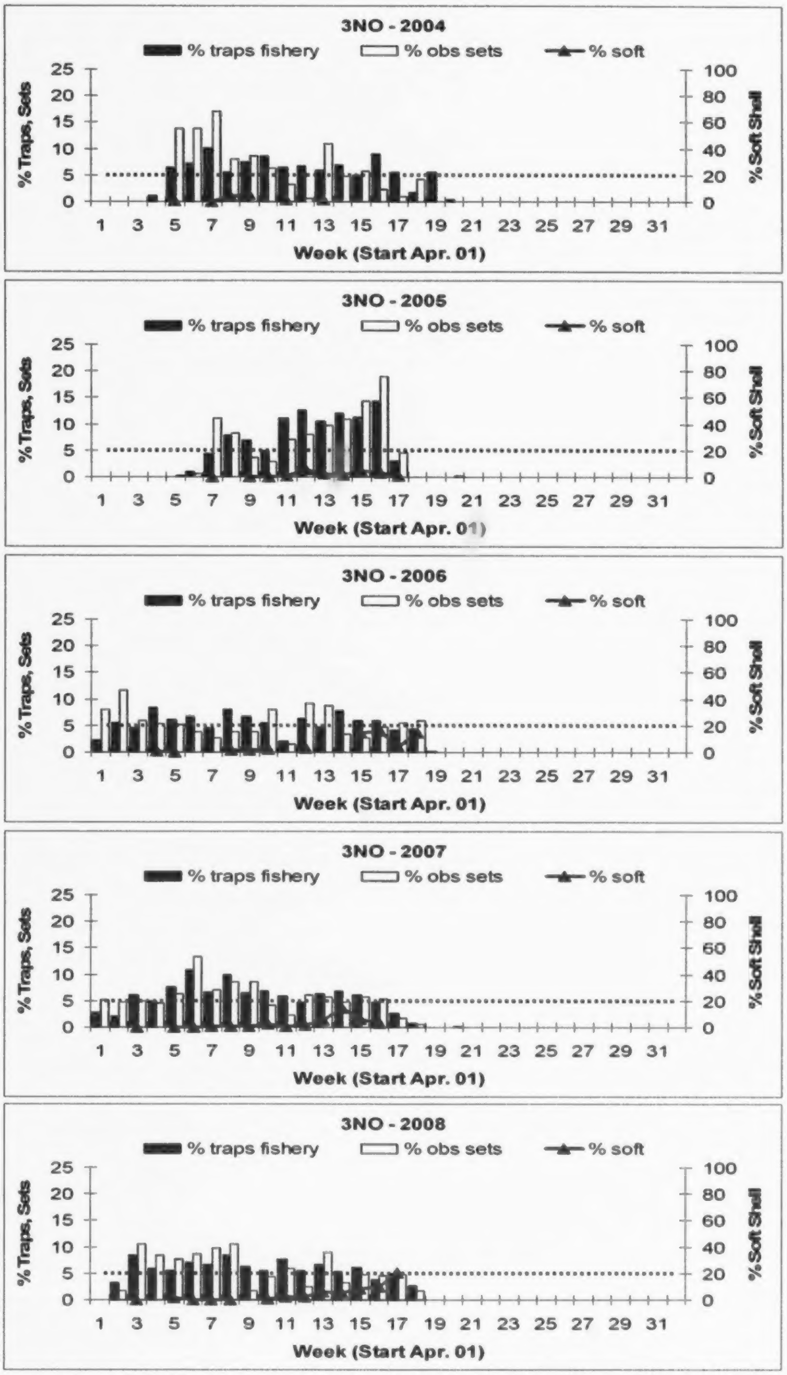


Figure 167. Seasonal trends in Division 3NO distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed)

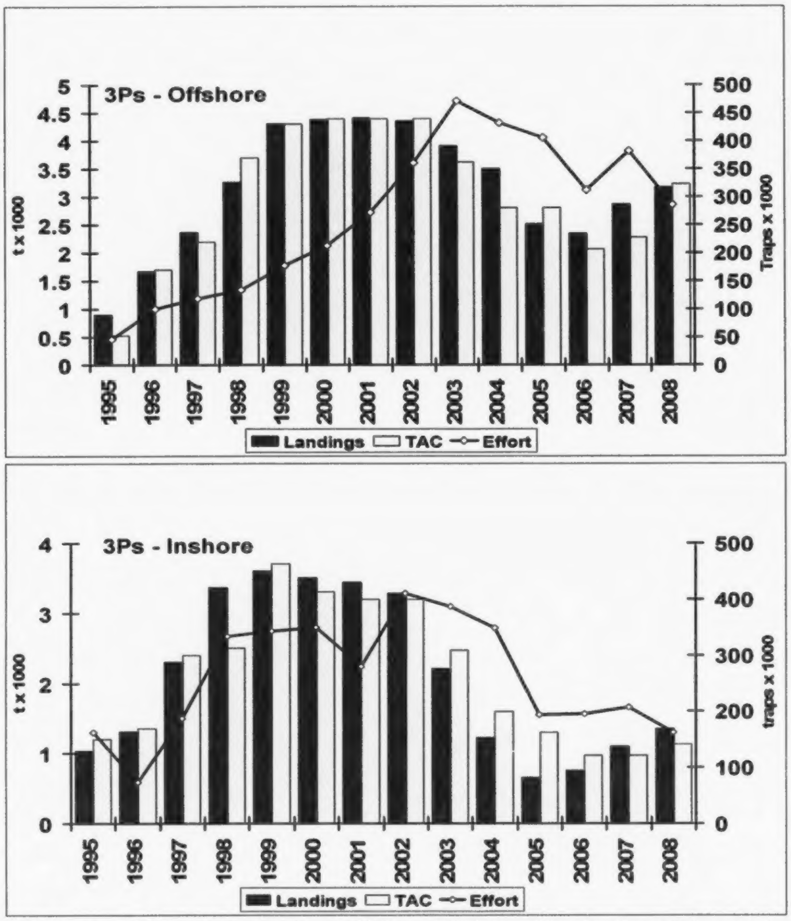


Figure 168. Trends in Subdivision 3Ps landings, TAC, and fishing effort for the offshore (above) and inshore (below).

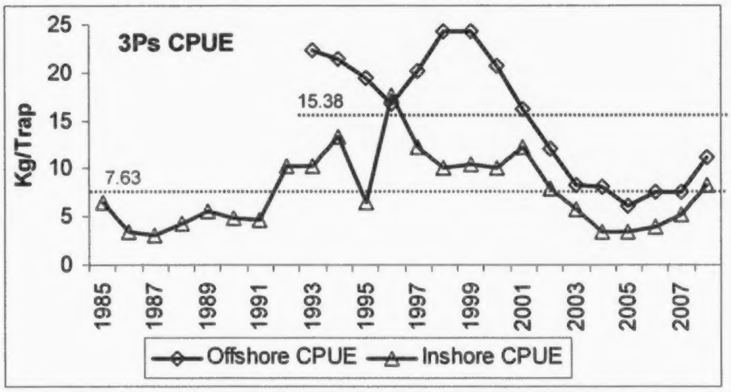


Figure 169. Trends in Subdivision 3Ps offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

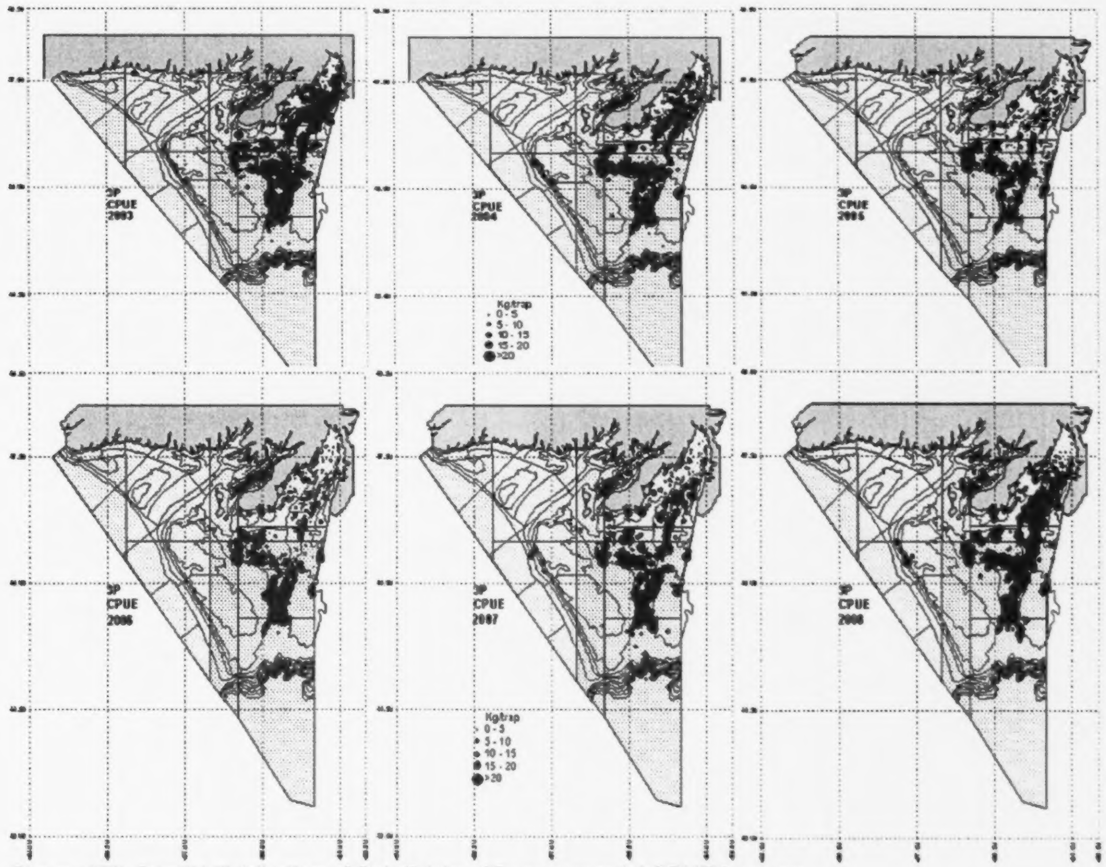

3P
CPUE
2003
3P
CPUE
2004
Kg/trap
0 - 5
5 - 10
10 - 15
15 - 20
>20
3P
CPUE
2005
3P
CPUE
2006
3P
CPUE
2007
Kg/trap
0 - 5
5 - 10
10 - 15
15 - 20
>20
3P
CPUE
2008

Figure 170. Spatial distribution of Subdivision 3Ps commercial CPUE by year.

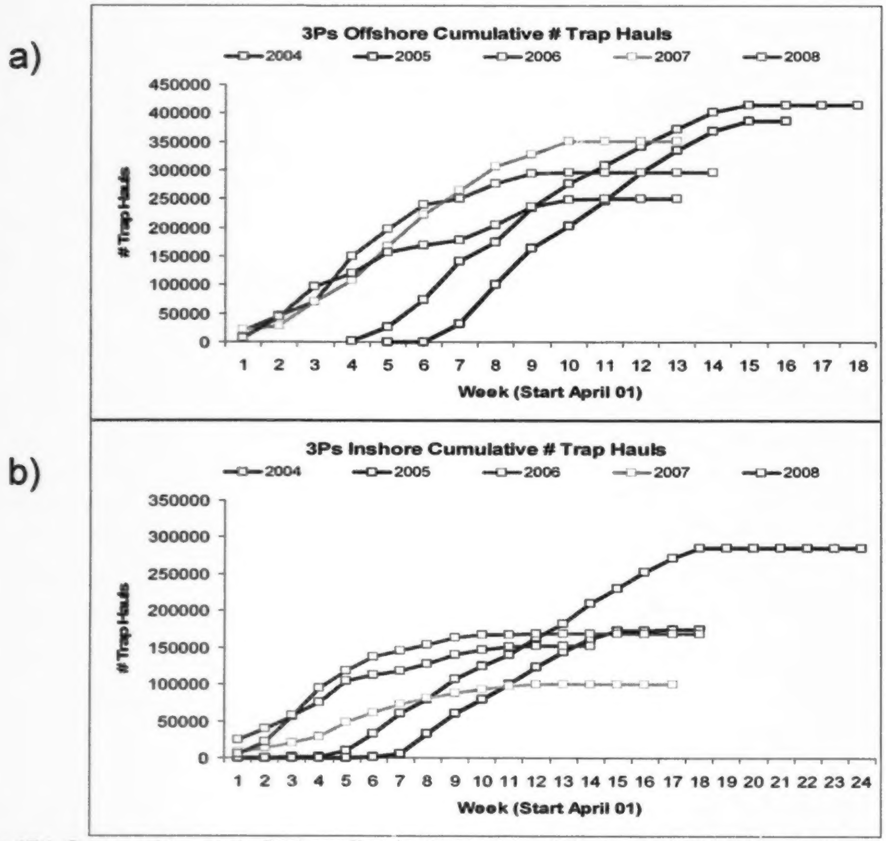


Figure 171. Seasonal trends in fishing effort for Subdivision 3Ps during 2004-08 for (a) the offshore and (b) the inshore.

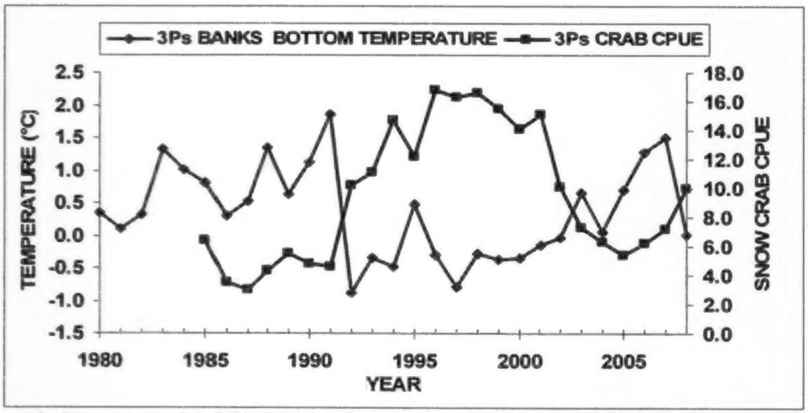


Figure 172. Trends in commercial CPUE in the Subdivision 3Ps fishery (offshore and inshore combined) vs. bottom temperature at a seven year lag.

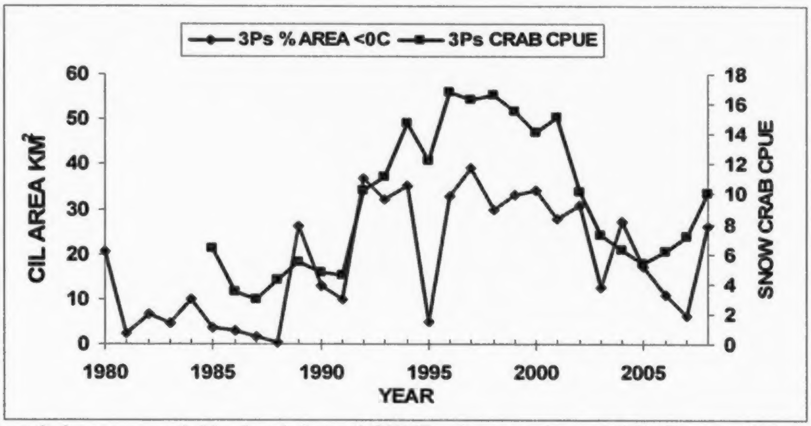


Figure 173. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Subdivision 3Ps offshore fishery.

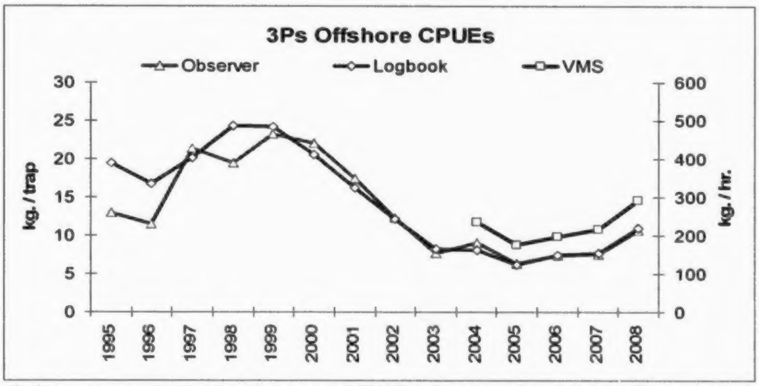


Figure 174. Trends in commercial logbook-based CPUE, observer-based CPUE, and VMS-based CPUE in the Subdivision 3Ps offshore fishery.

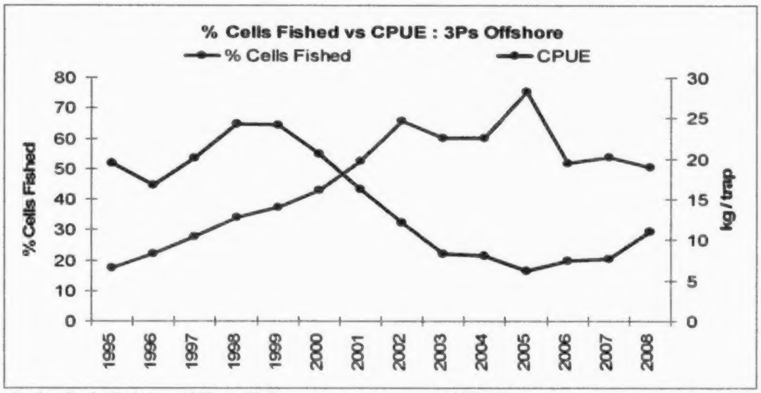


Figure 175. Trends in Subdivision 3Ps offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

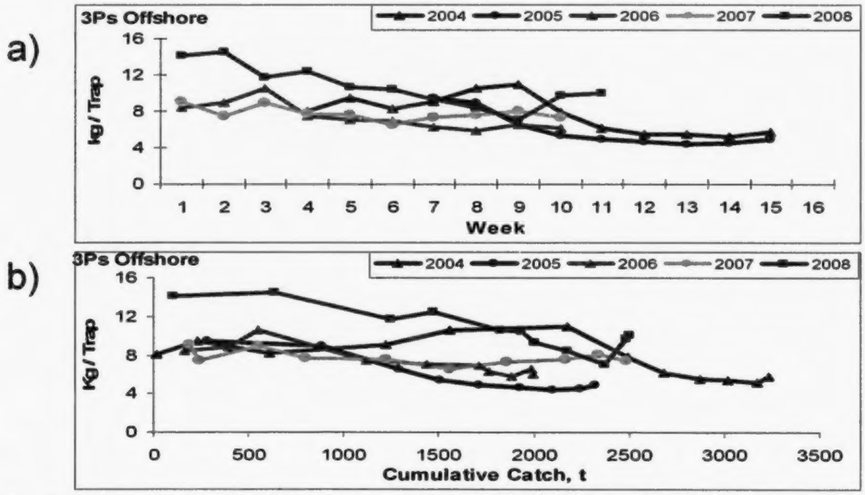


Figure 176. Seasonal trends in logbook-based CPUE for Subdivision 3Ps offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

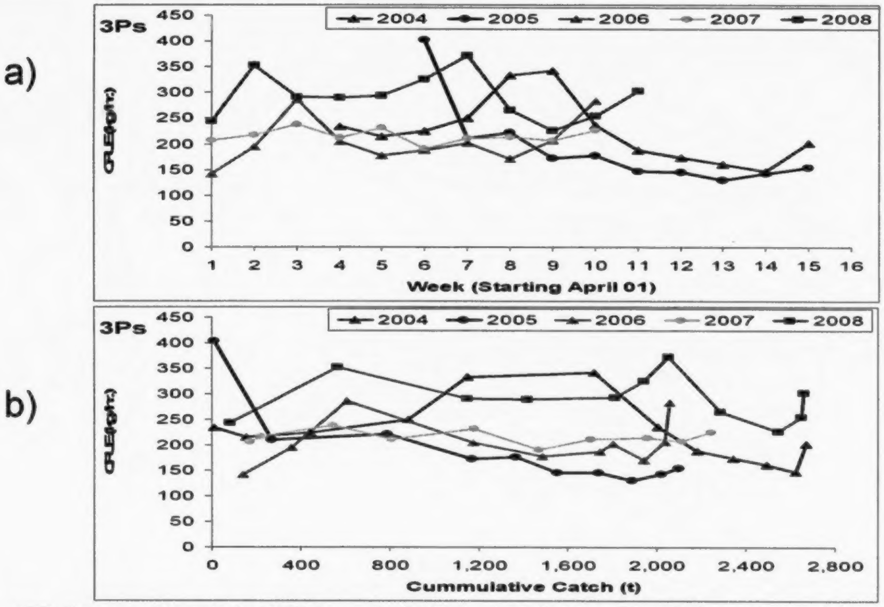


Figure 177. Seasonal trends in VMS-based CPUE for Subdivision 3Ps offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

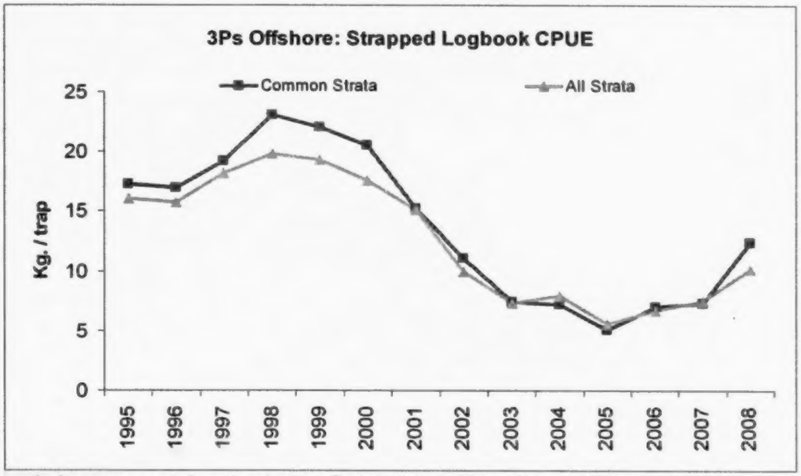


Figure 178. Trends in mean catch rates in the Subdivision 3Ps offshore fishery based on spatially-expanded logbook STRAP analysis.

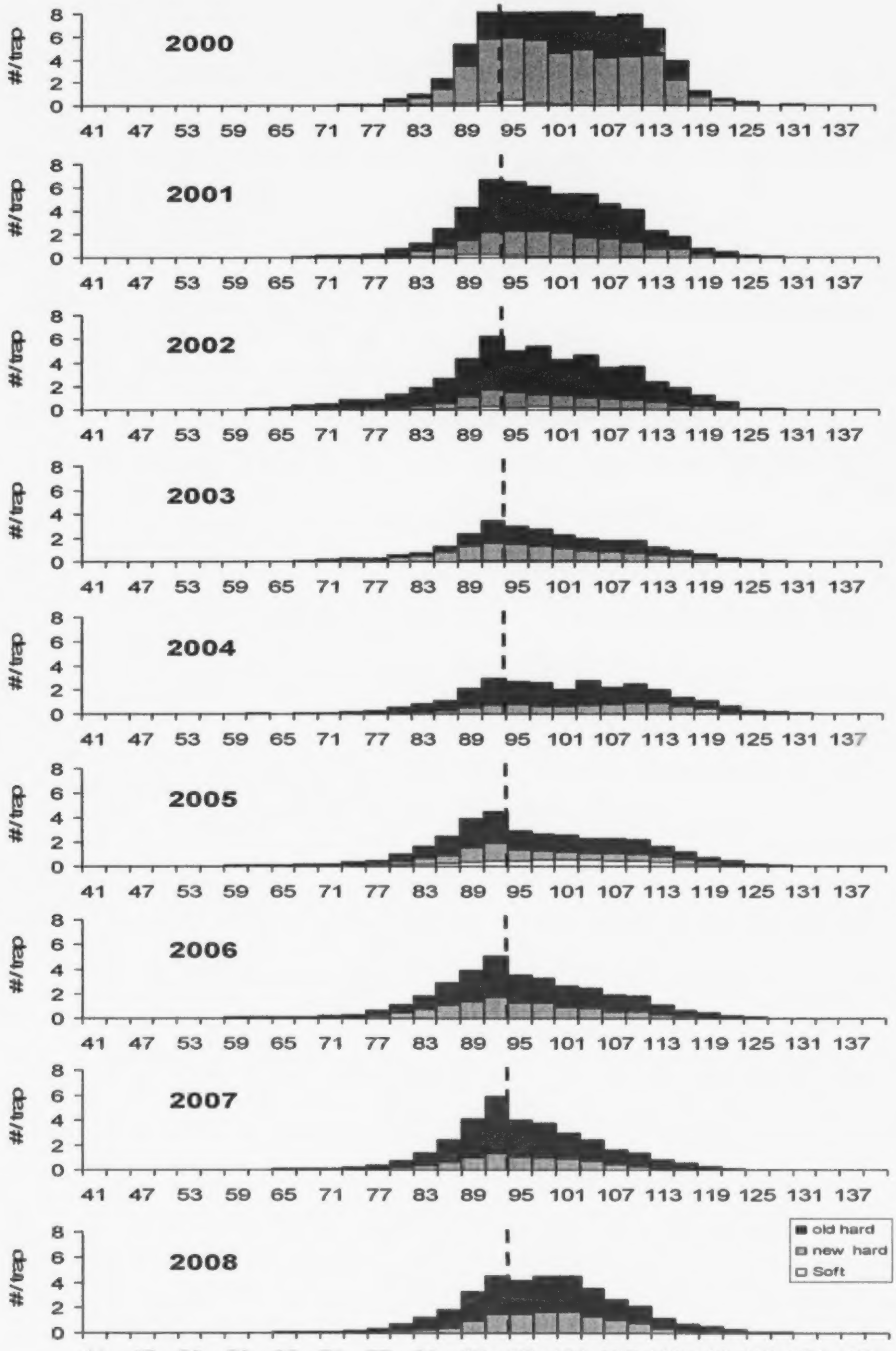


Figure 179. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdivision 3Ps offshore. The vertical dashed line indicates the minimum legal size.

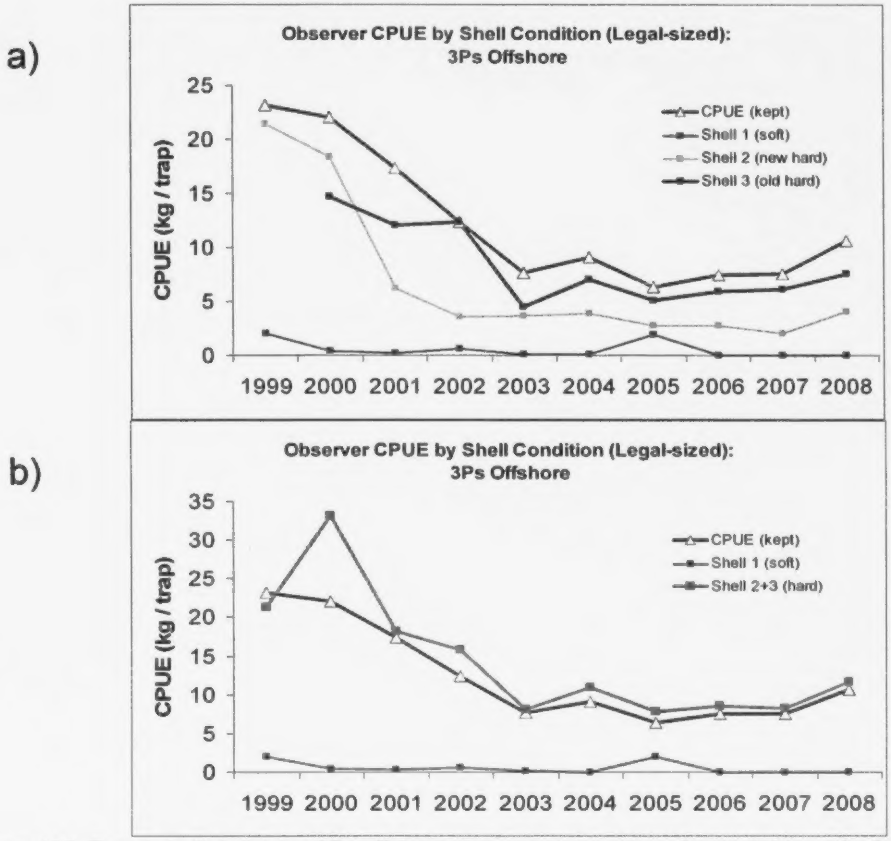


Figure 180. Trends in Subdivision 3Ps offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

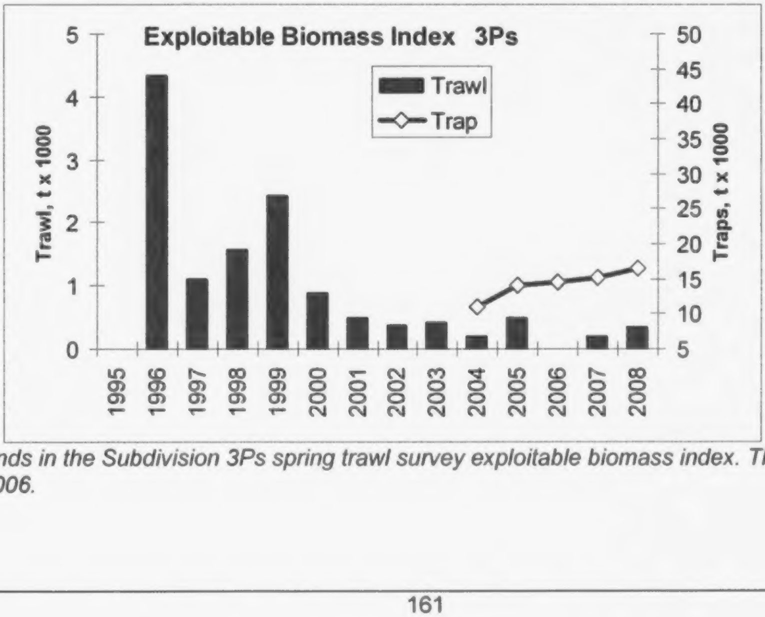


Figure 181. Trends in the Subdivision 3Ps spring trawl survey exploitable biomass index. The survey was incomplete in 2006.

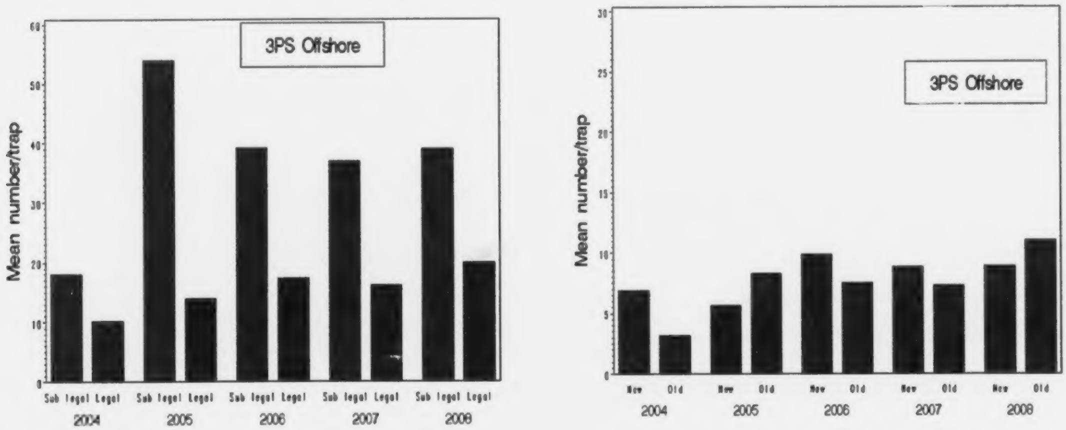


Figure 182. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Subdivision 3Ps inshore industry-DFO collaborative post-season trap survey.

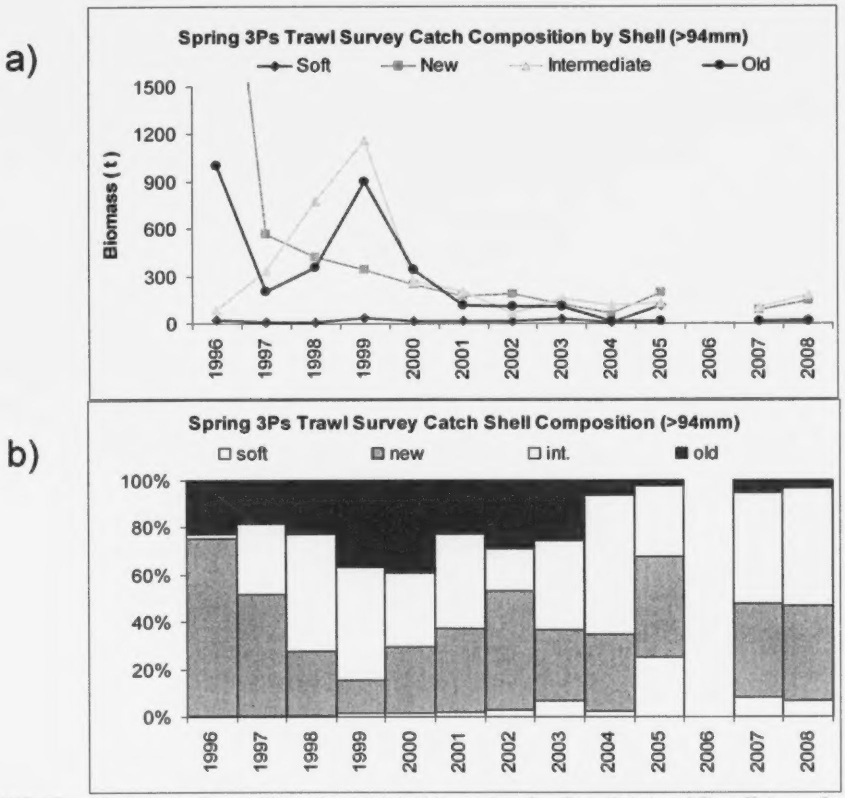


Figure 183. Trends, by shell condition, in exploitable males for Subdivision 3Ps offshore from fall trawl surveys for; a) biomass, and (b) percentages of the total catch. The survey was incomplete in 2006.

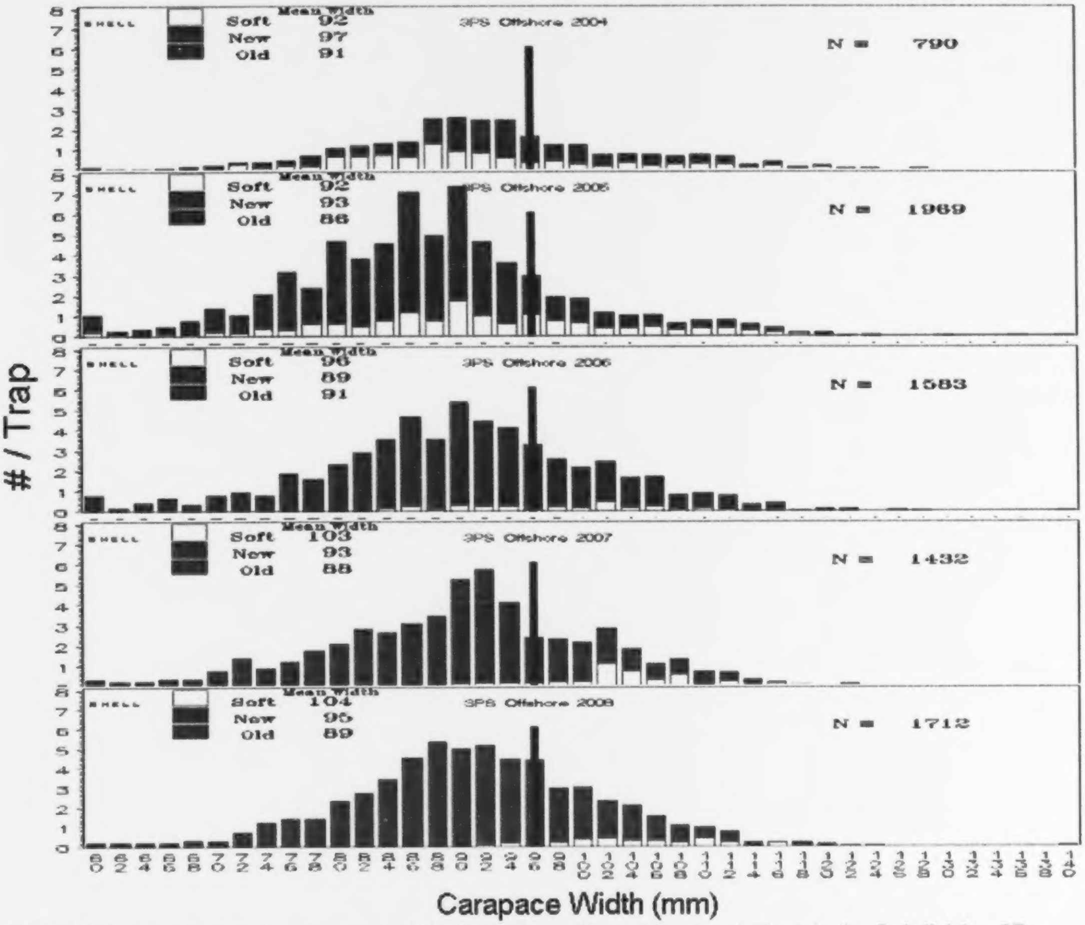


Figure 184. Trends in male carapace width distributions from common stations in the Subdivision 3Ps industry-DFO post-season trap survey. The vertical solid line indicates the minimum legal size.

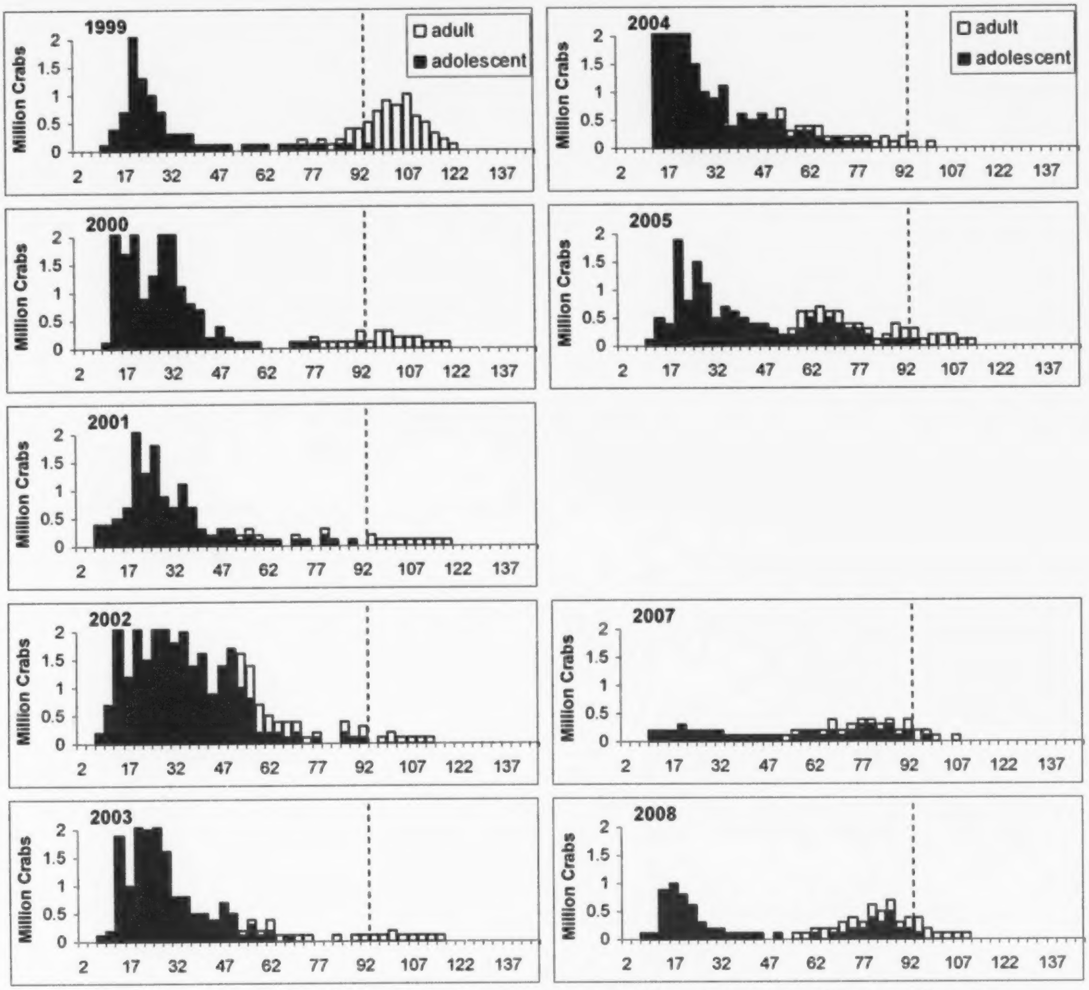


Figure 185. Distribution of abundance (index) by carapace width for Subdivision 3Ps juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

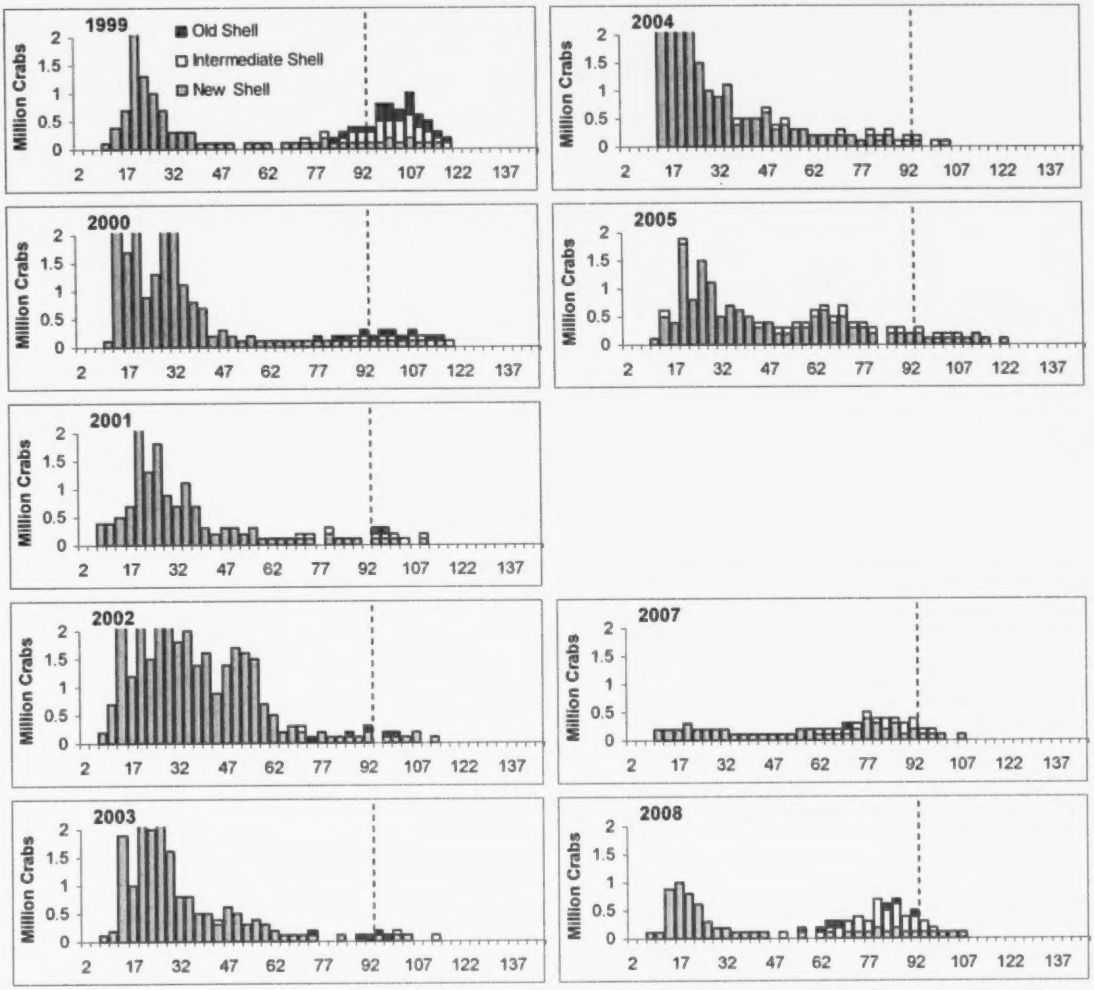


Figure 186. Distribution of abundance (index) by carapace width and shell condition from spring trawl surveys for Subdivision 3Ps. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

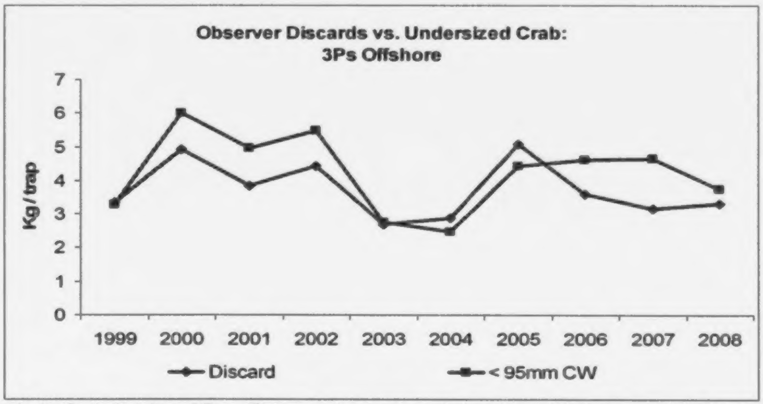


Figure 187. Trends in Subdivision 3Ps offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

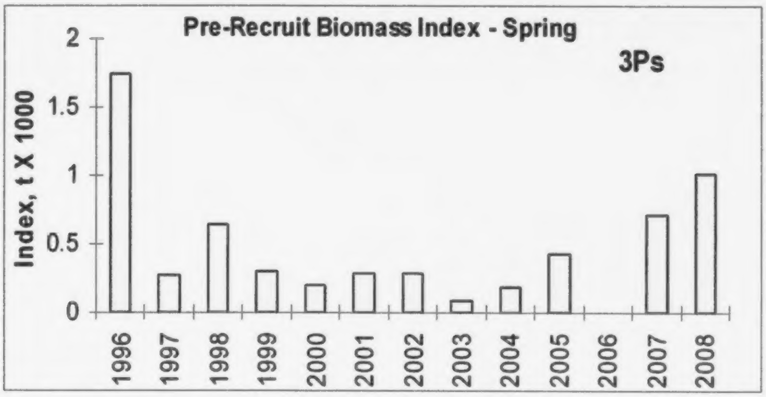


Figure 188. Trends in the Subdivision 3Ps spring trawl survey pre-recruit biomass index. The survey was incomplete in 2006.

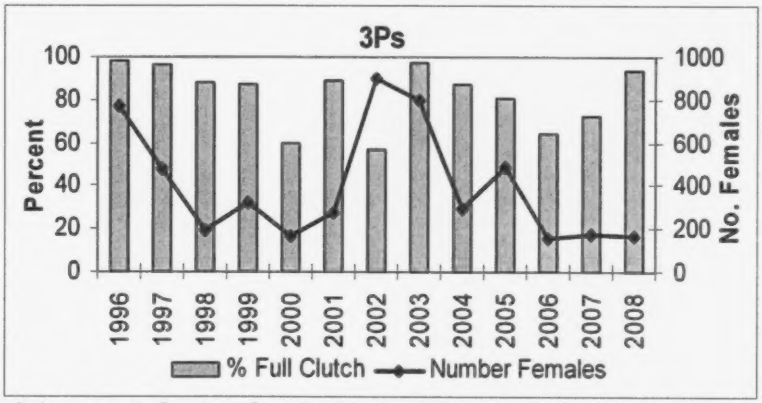


Figure 189. Trends in percent of mature females bearing full clutches of viable eggs and sample sizes in Subdivision 3Ps from fall multi-species surveys. The survey was incomplete in 2006.

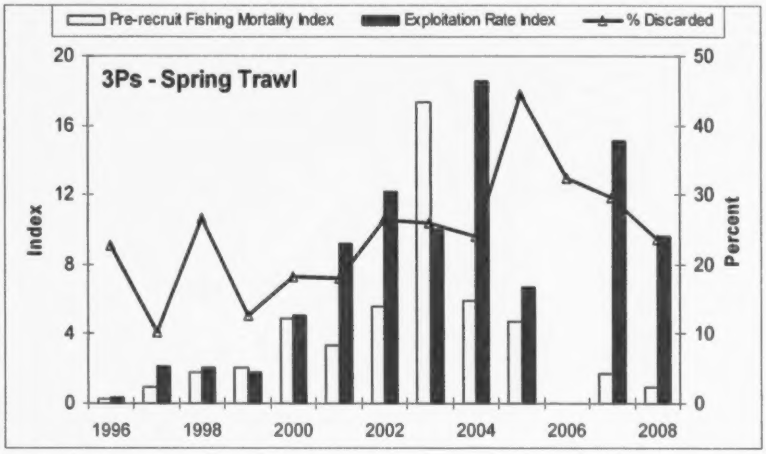


Figure 190. Trends in Subdivision 3Ps offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. (No 2006 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2006 survey).

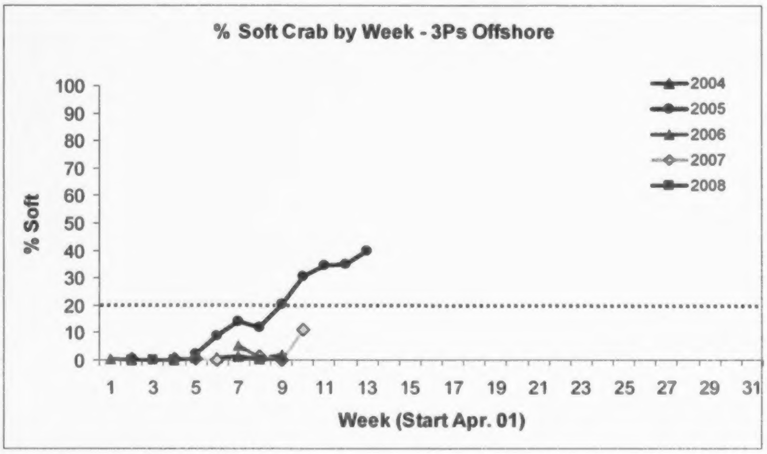


Figure 191. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Subdivision 3Ps offshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

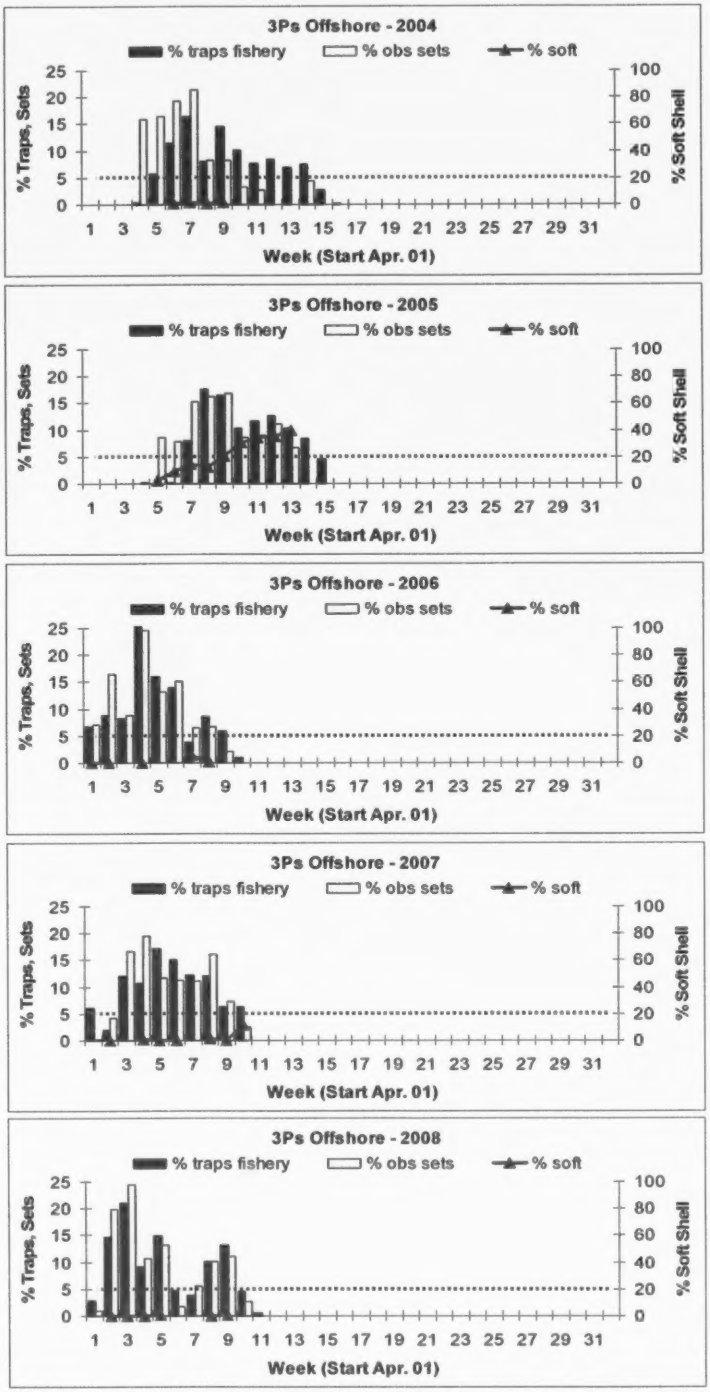


Figure 192. Seasonal trends in Subdivision 3Ps offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed)

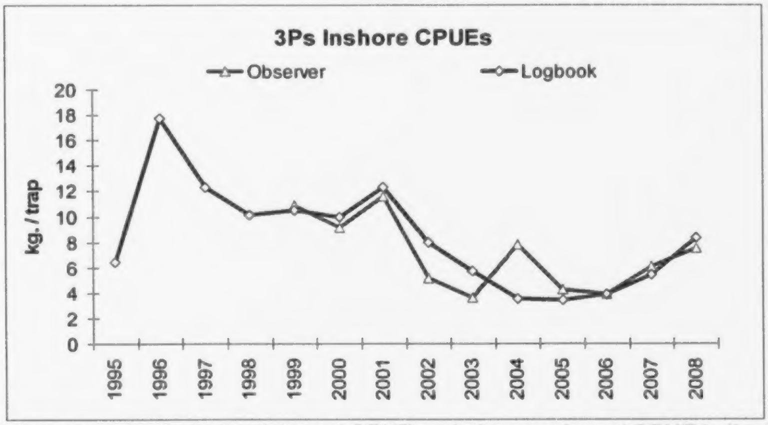


Figure 193. Trends in commercial logbook-based CPUE and observer-based CPUE in the Subdivision 3Ps inshore fishery.

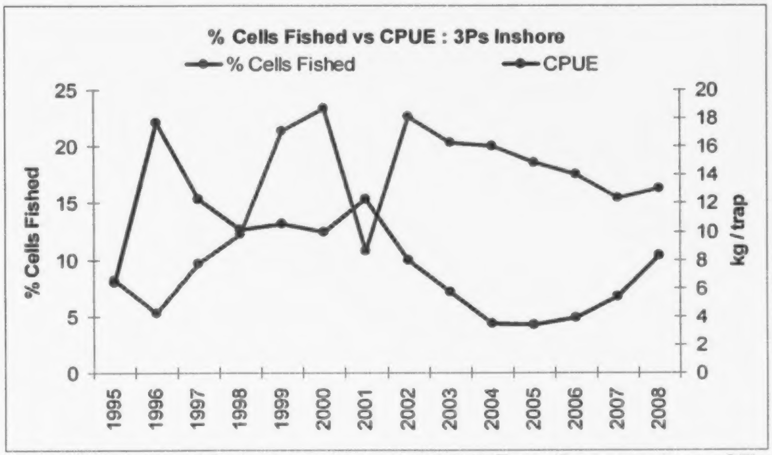


Figure 194. Trends in Subdivision 3Ps inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

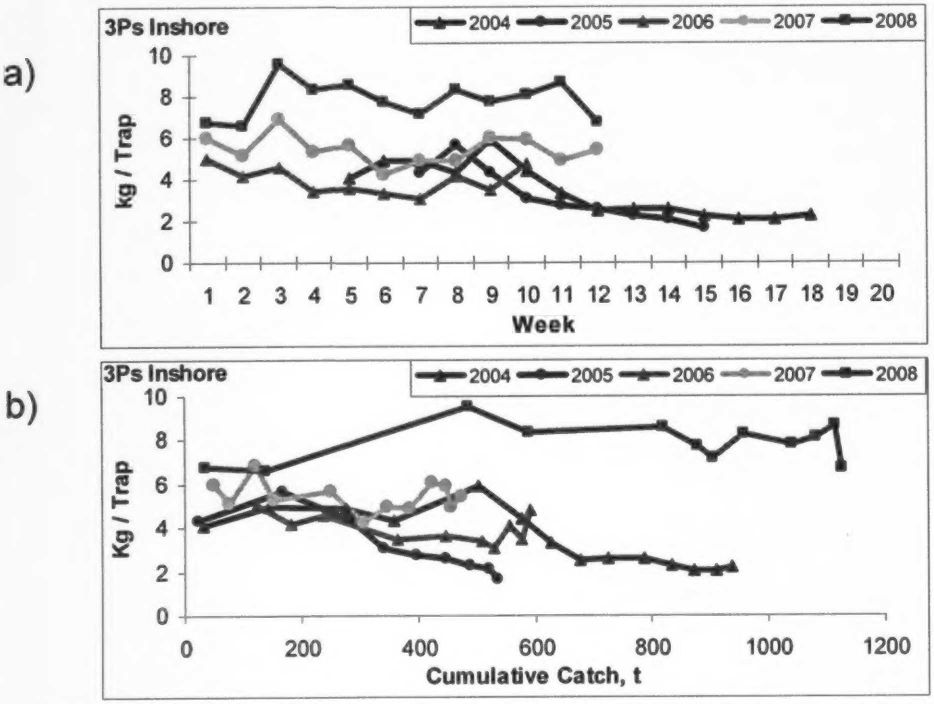


Figure 195. Seasonal trends in logbook-based CPUE for Subdivision 3Ps inshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

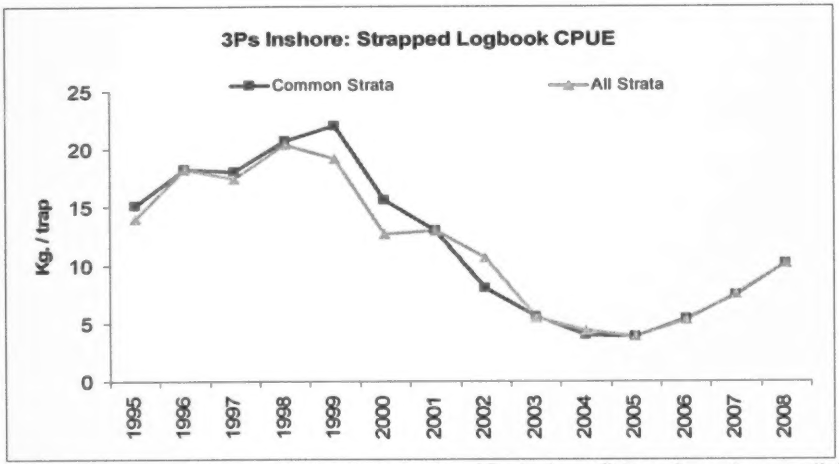


Figure 196. Trends in mean catch rates in the Subdivision 3Ps inshore fishery based on spatial-expanded logbook STRAP analysis.

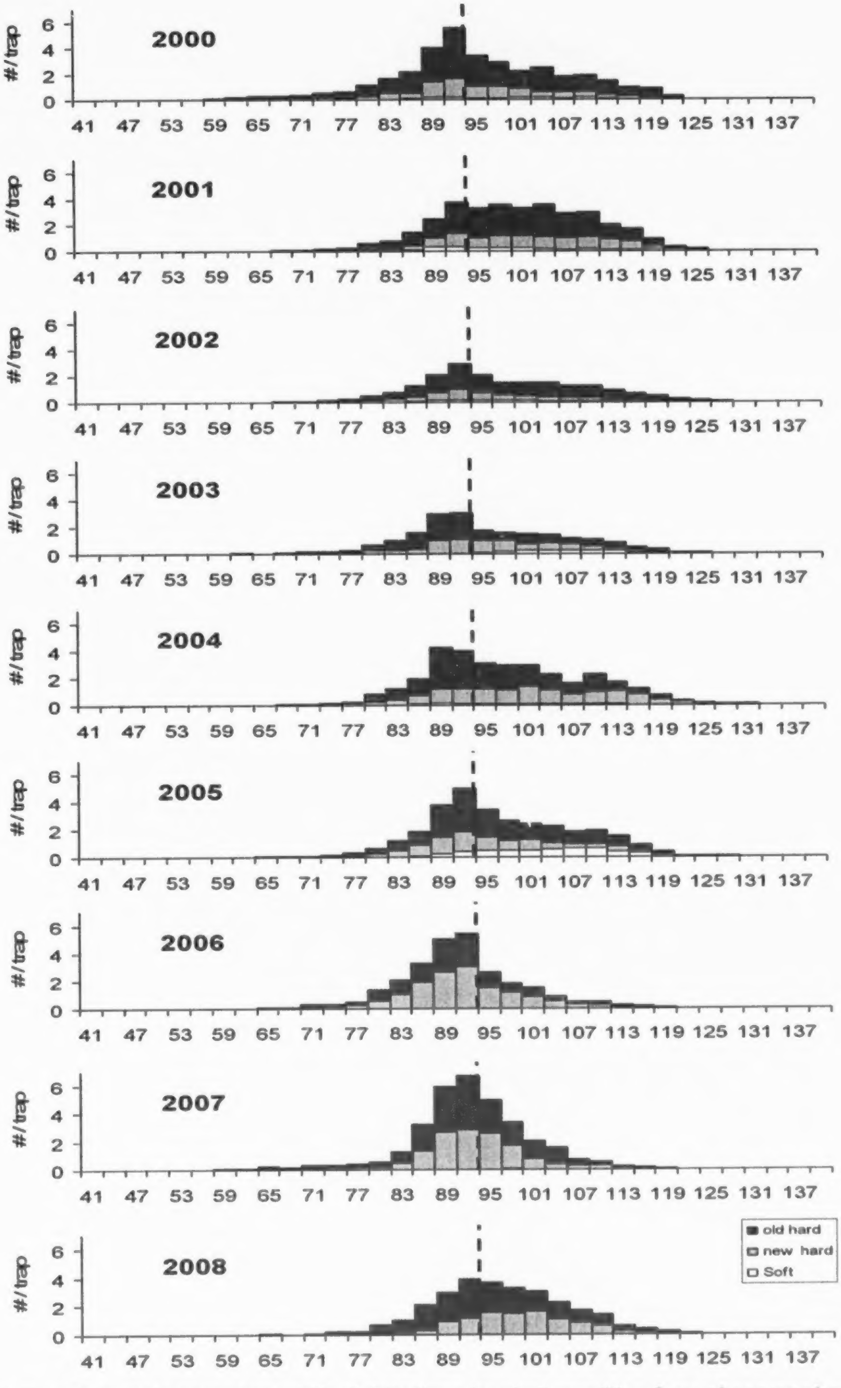


Figure 197. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdivision 3Ps inshore. The vertical dashed line indicates the minimum legal size.

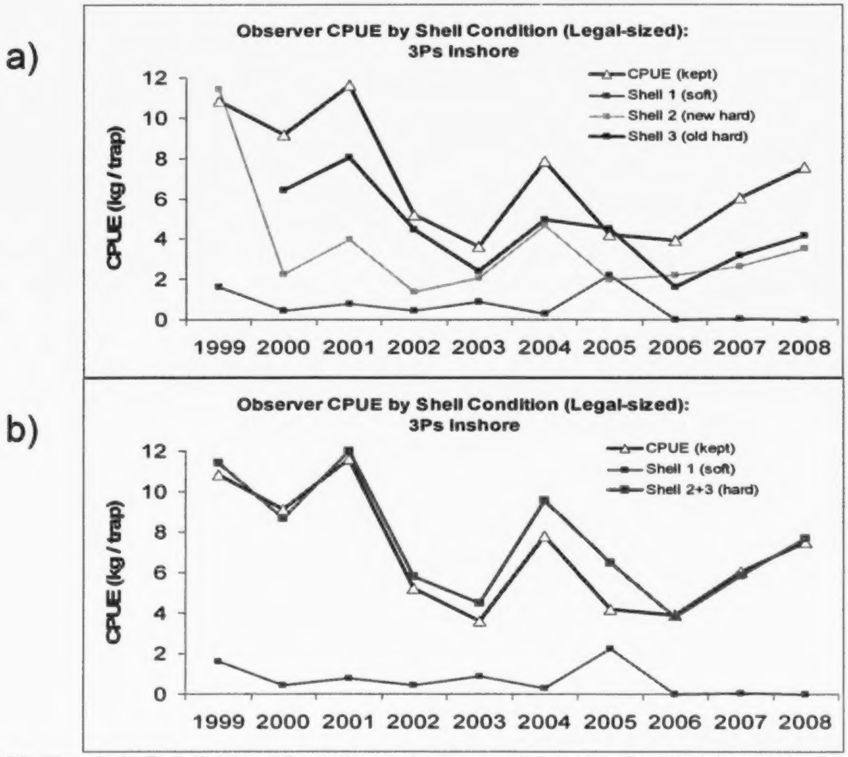


Figure 198. Trends in Subdivision 3Ps inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

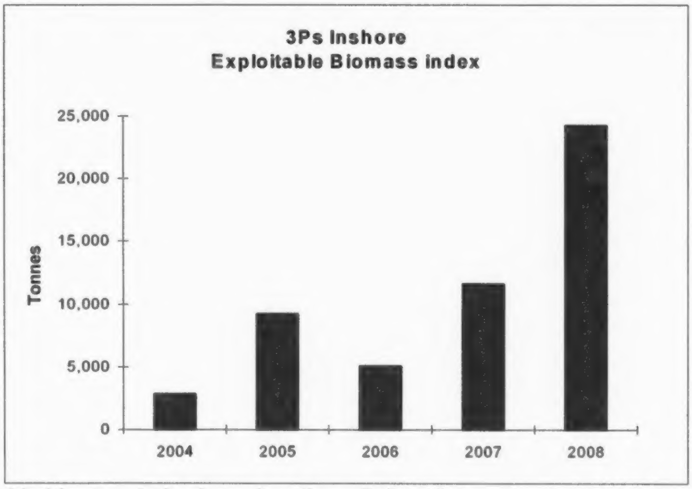


Figure 199. Exploitable biomass index based on the collaborative post-season trap survey in inshore Subdivision 3Ps.

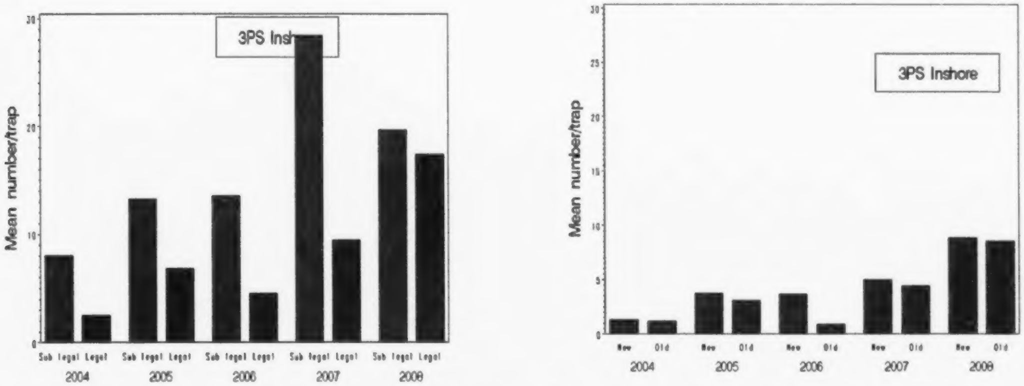


Figure 200. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Subdivision 3Ps inshore industry-DFO collaborative post-season trap survey.

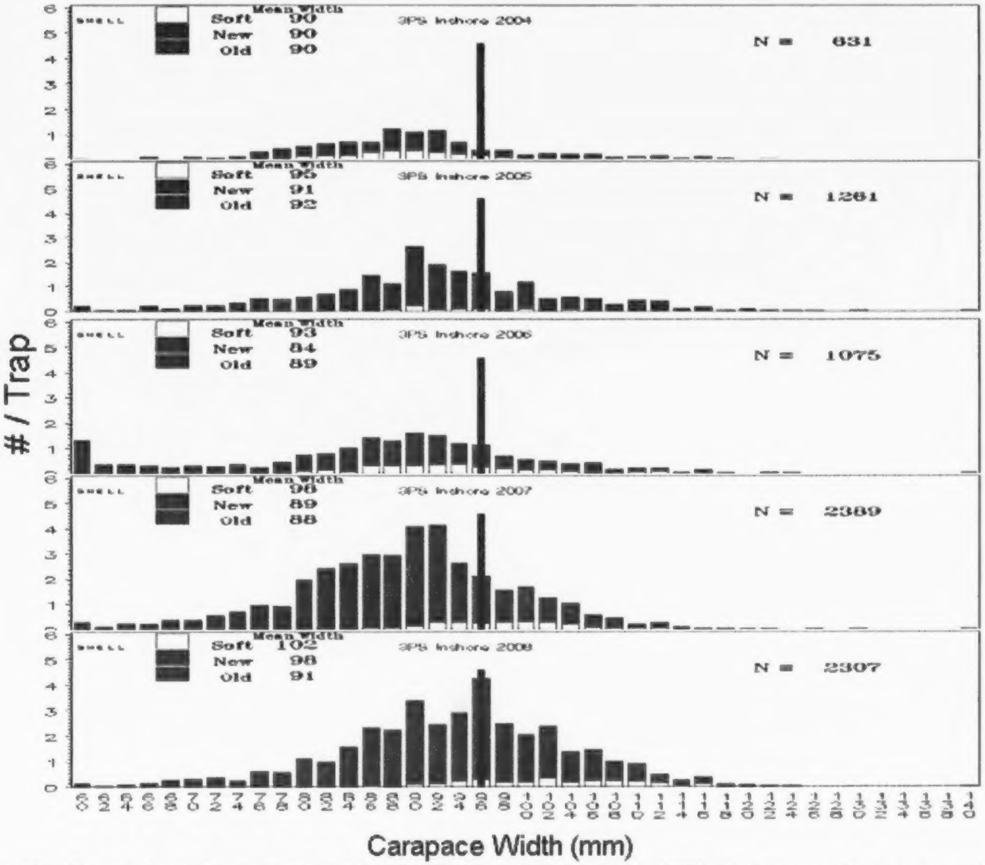


Figure 201. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Subdivision 3Ps inshore. The vertical solid line indicates the minimum legal size.

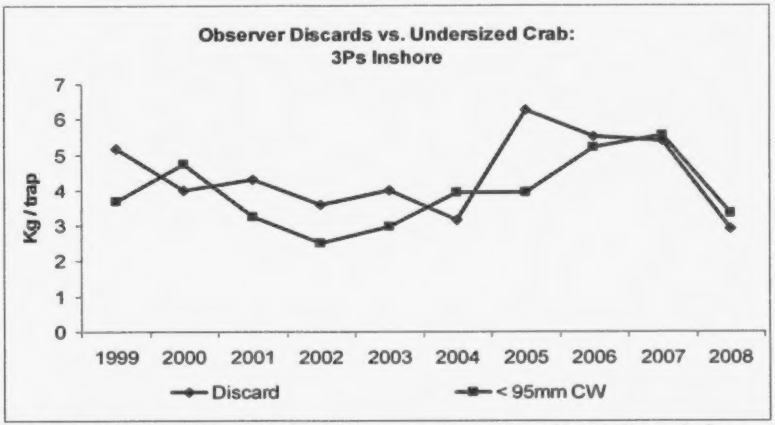


Figure 202. Trends in Subdivision 3Ps inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

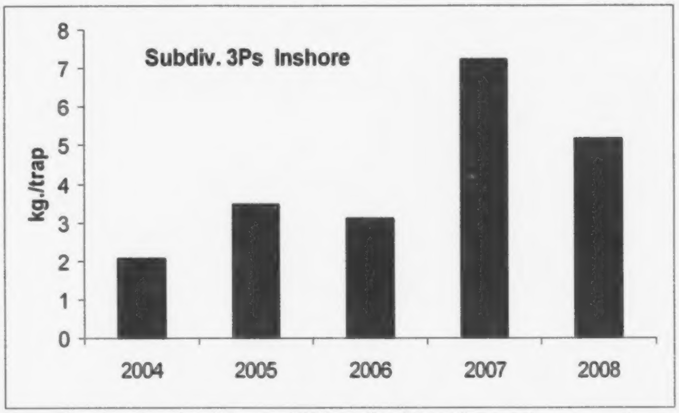


Figure 203. Catch rates of undersized (<95 mm CW) crabs from the post-season trap survey in inshore Subdivision 3Ps.

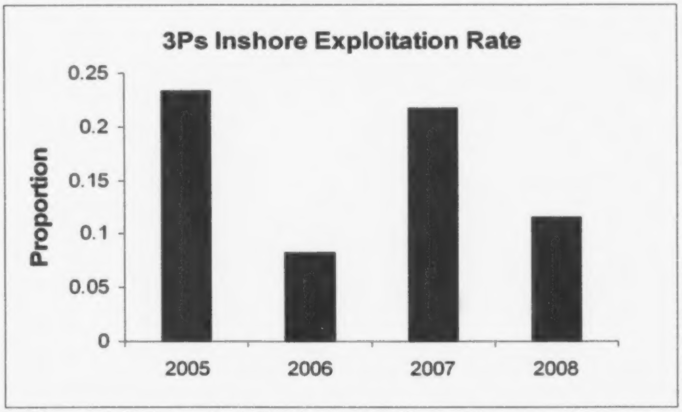


Figure 204. Trends in the exploitation rate index based on the post-season trap survey in Subdivision 3Ps

inshore.

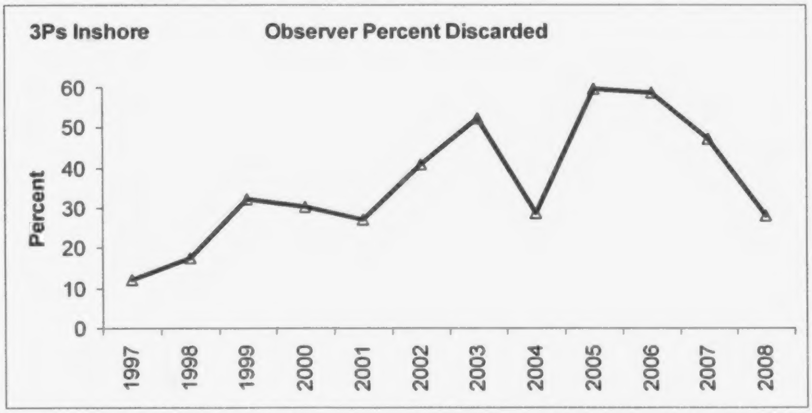


Figure 205. Trends in Subdivision 3Ps inshore percentage of the catch discarded in the fishery.

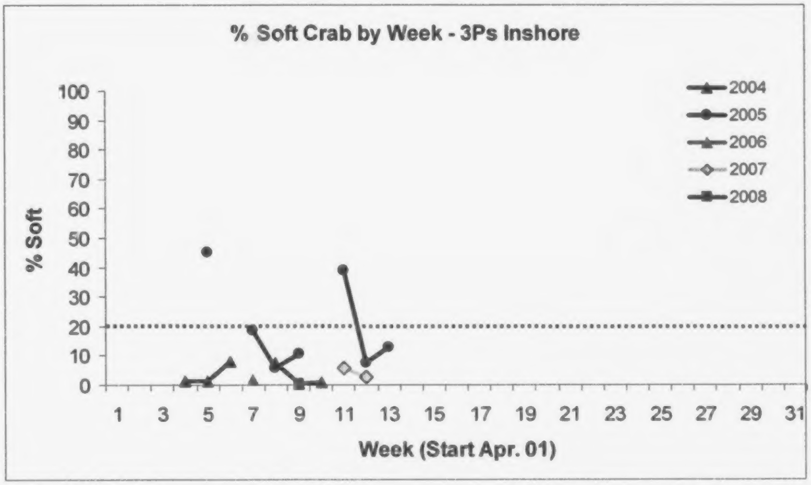


Figure 206. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Subdivision 3Ps inshore fishery that are soft-shelled, by year (2004-08), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed)

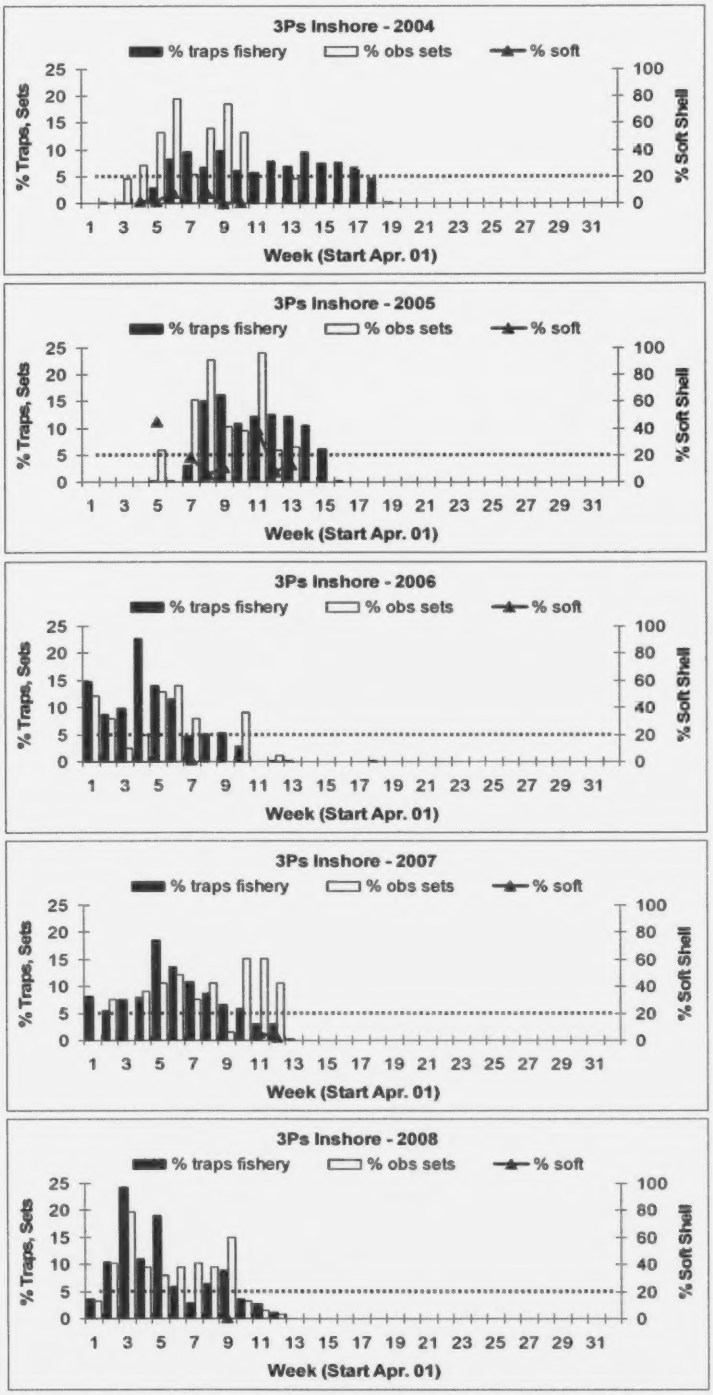


Figure 207. Seasonal trends in Subdivision 3Ps inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2004-08. (Sample sizes of <10 observed sets/week removed)

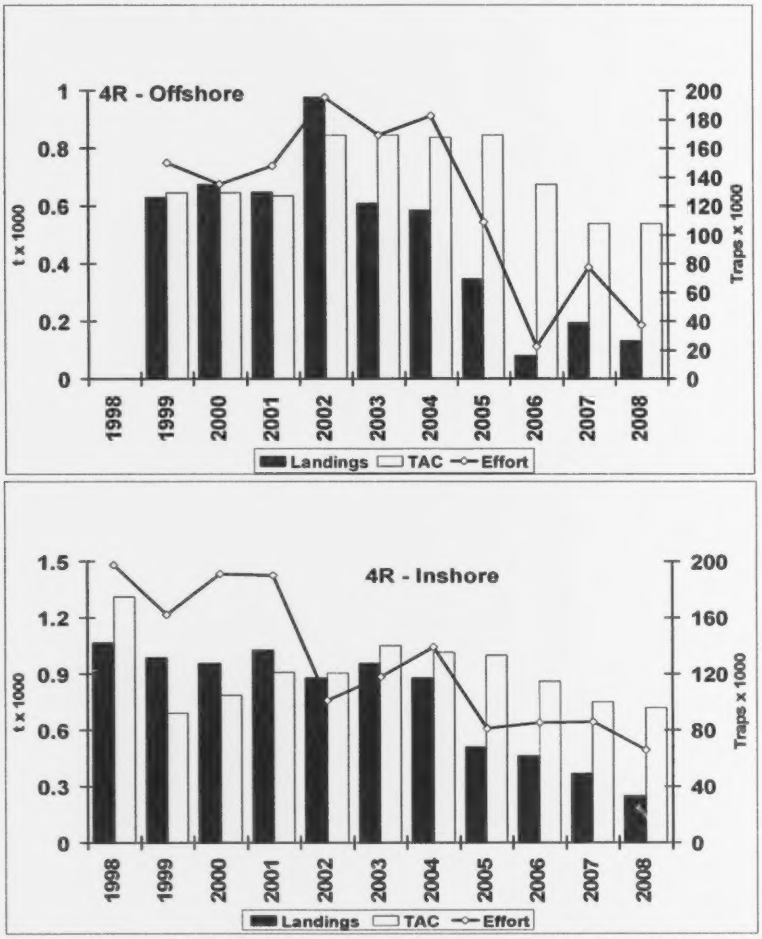


Figure 208. Trends in Division 4R3Pn landings, TAC, and fishing effort for the offshore (above) and inshore (below).

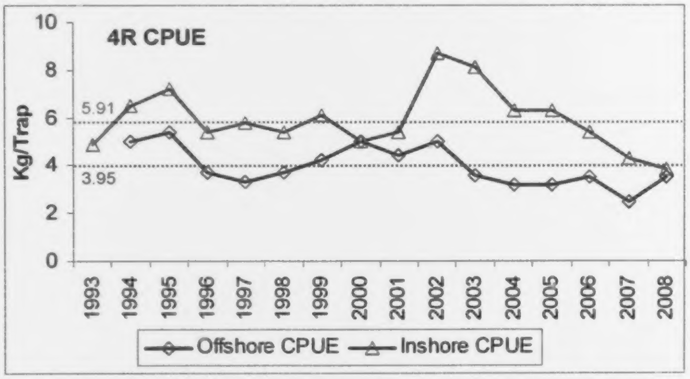


Figure 209. Trends in Division 4R3Pn offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

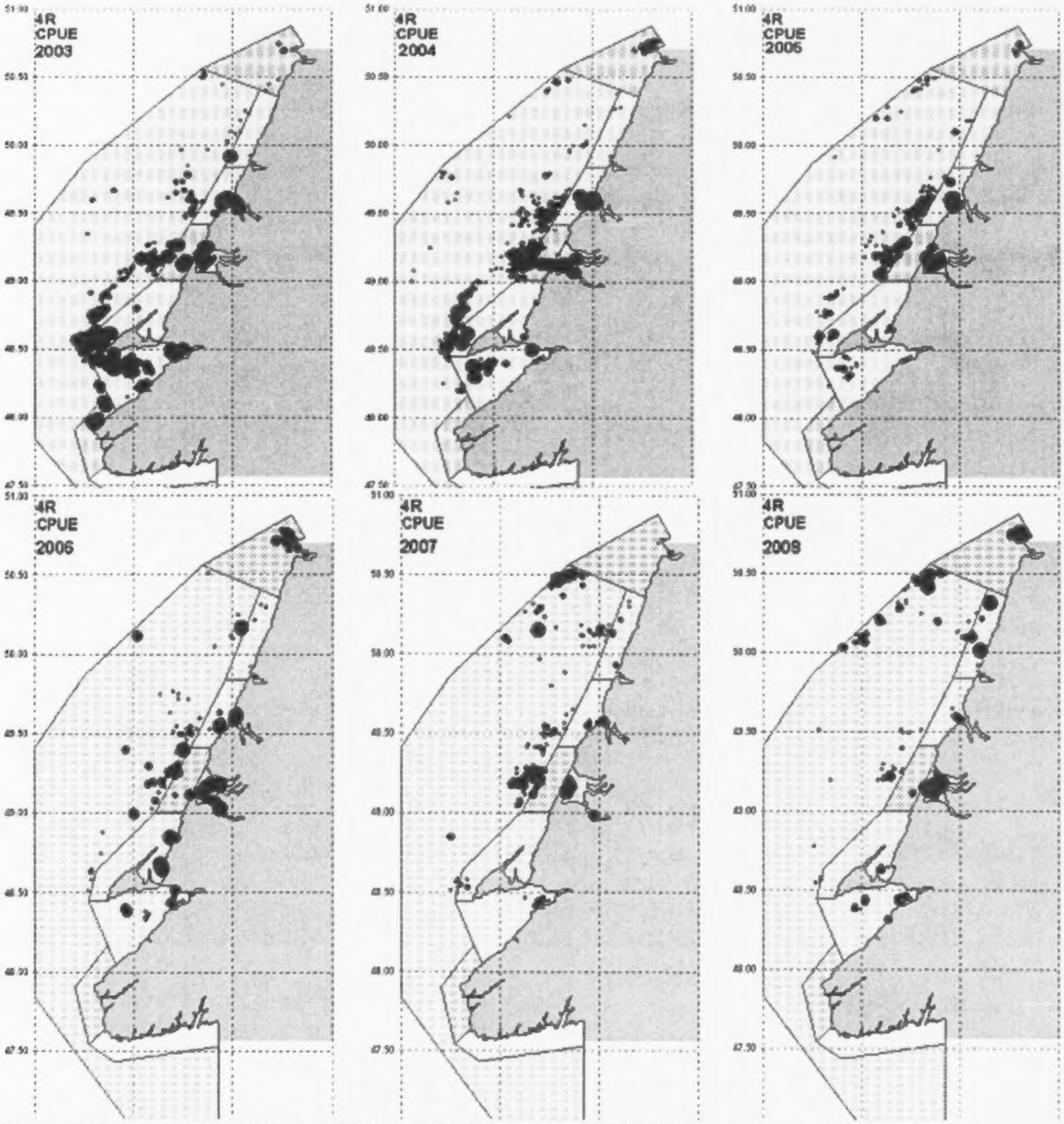

4R
CPUE
2003
4R
CPUE
2004
4R
CPUE
2005
4R
CPUE
2006
4R
CPUE
2007
4R
CPUE
2008
51.00
50.50
50.00
49.50
49.00
48.50
48.00
47.50

Figure 210. Spatial distribution of Division 4R3Pn commercial CPUE by year.

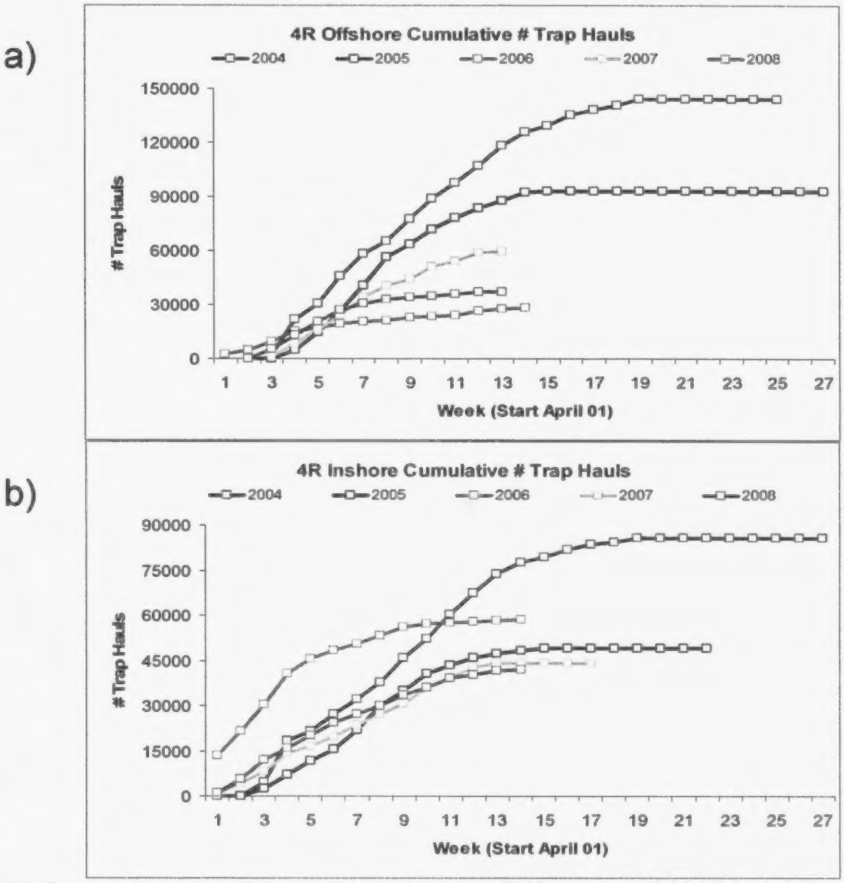


Figure 211. Seasonal trends in fishing effort for Division 4R3Pn during 2004-08 for (a) the offshore and (b) the inshore.

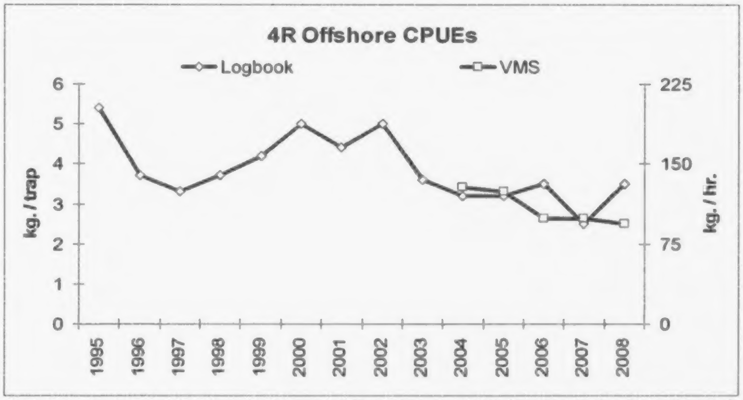


Figure 212. Trends in commercial logbook-based CPUE and VMS-based CPUE in the Division 4R3Pn offshore fishery.

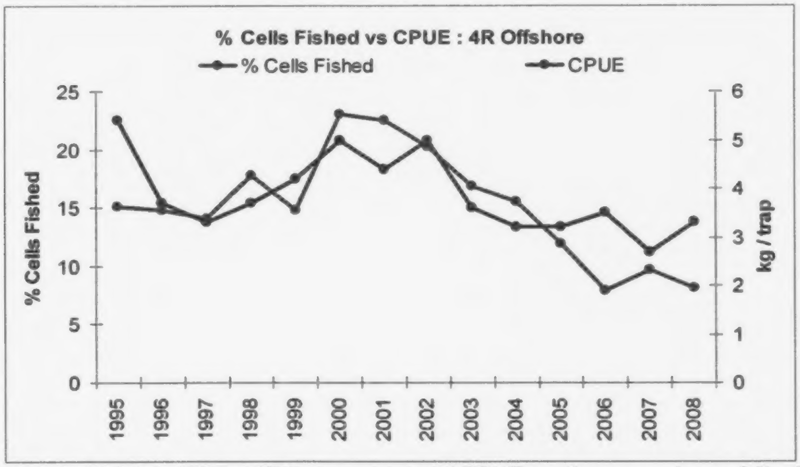


Figure 213. Trends in Division 4R3Pn offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

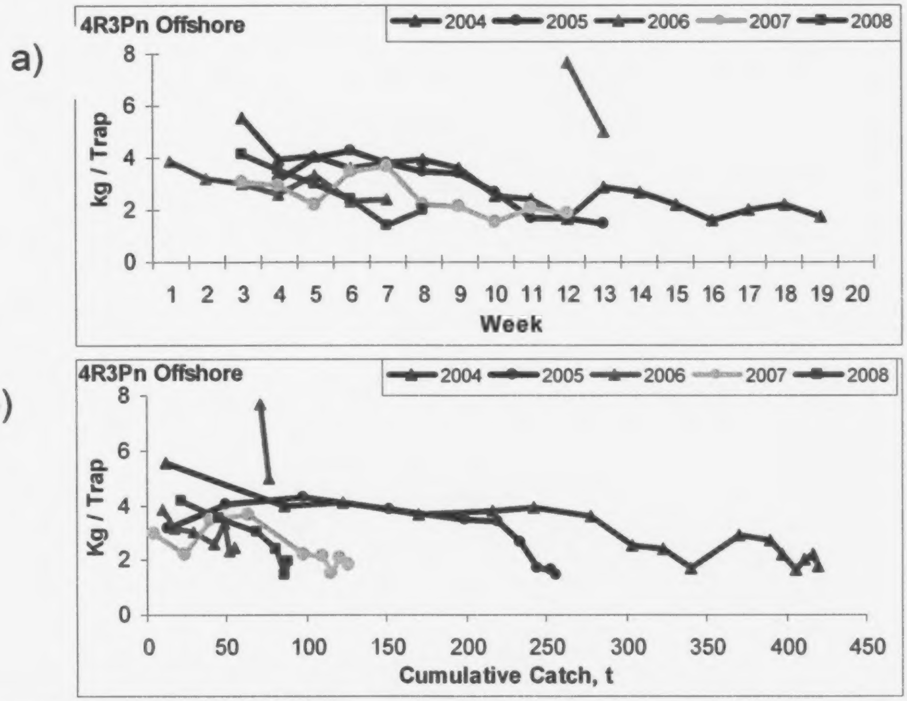


Figure 214. Seasonal trends in logbook-based CPUE for Division 4R3Pn offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

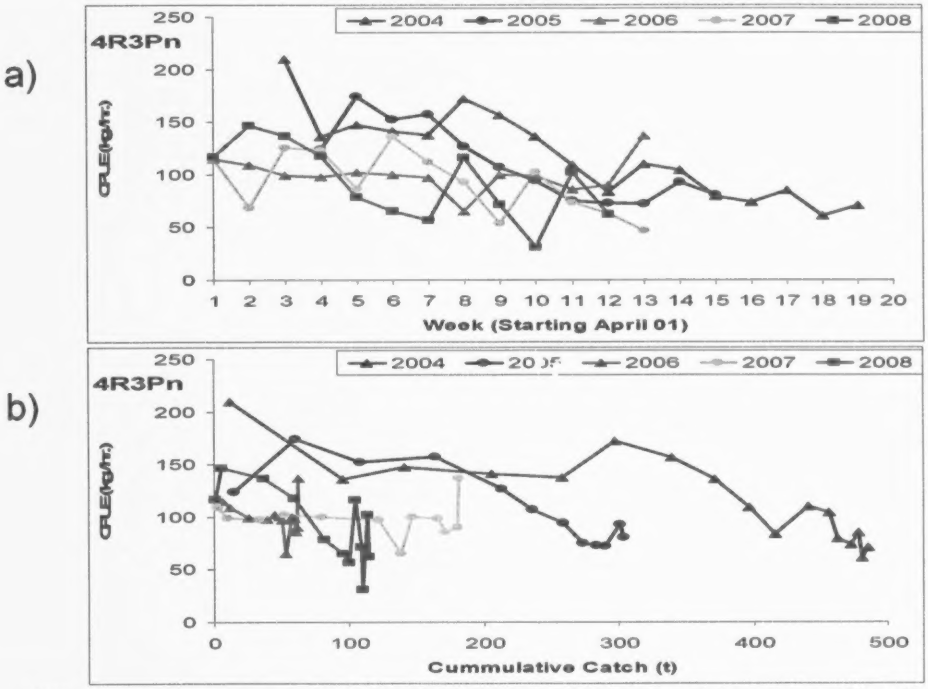


Figure 215. Seasonal trends in VMS-based CPUE for Division 4R3Pn offshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

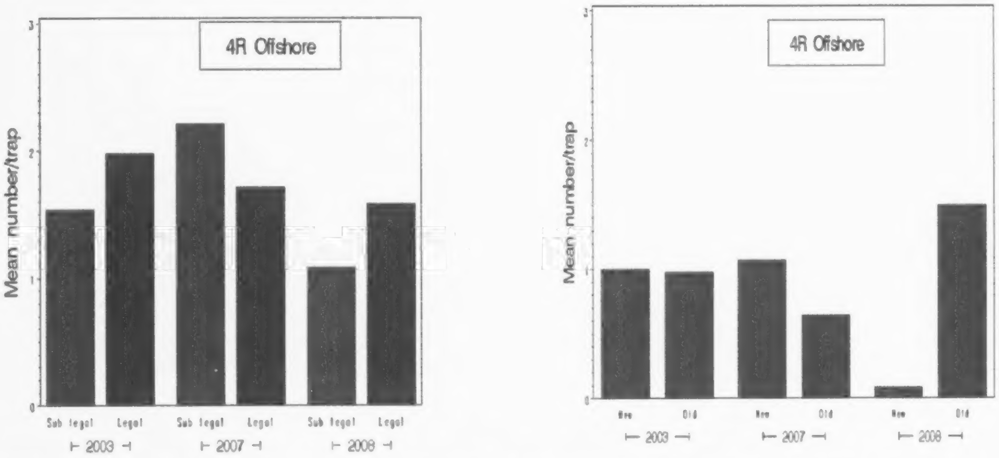


Figure 216. Trends in CPUE by size group (left) and by shell condition for legal-sized crabs (right) from common stations in the Division 4R3Pn offshore industry-DFO collaborative post-season trap survey.

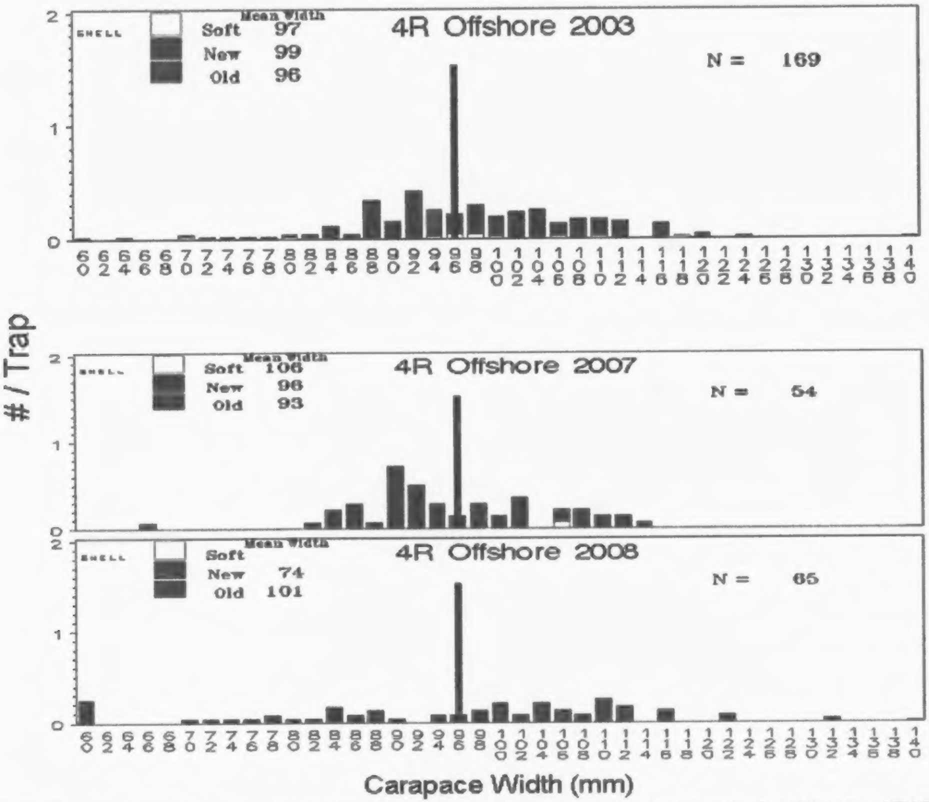


Figure 217. Trends in male carapace width distributions from common stations in the Division 4R3Pn offshore industry-DFO collaborative post-season trap survey. The vertical solid line indicates the minimum legal size.

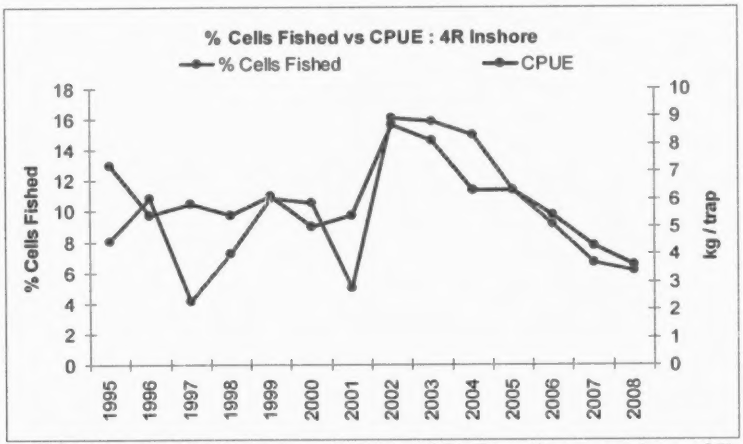


Figure 218. Trends in Division 4R3Pn inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

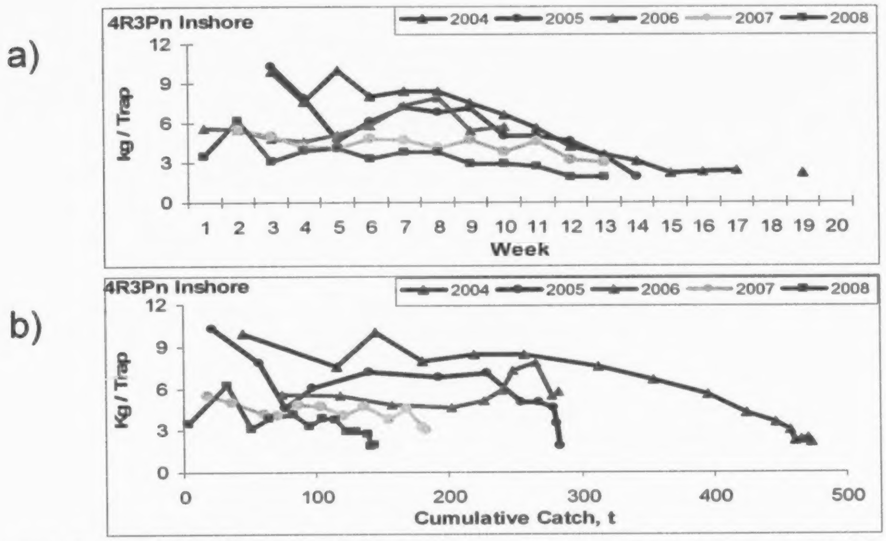


Figure 219. Seasonal trends in logbook-based CPUE for Division 4R3Pn inshore during 2004-08; (a) by week, and (b) in relation to cumulative catch.

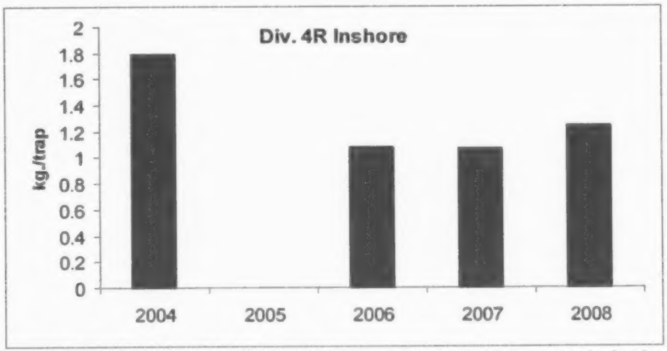


Figure 220. Catch rates of legal-sized crabs from the post-season trap survey in inshore Division 4R3Pn.

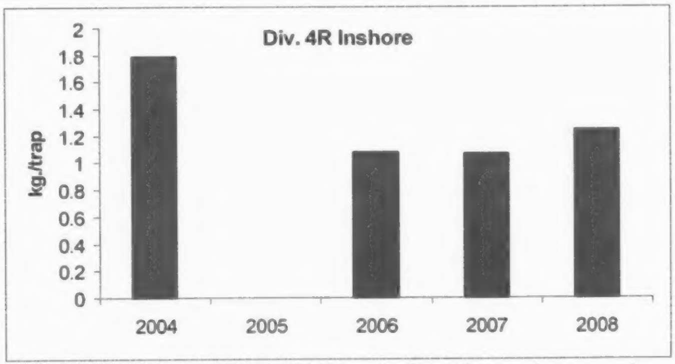


Figure 221. Catch rates of undersized (<95 mm CW) crabs from the post-season trap survey in inshore Division 4R3Pn.